The Blast Furnace and Steel Plant

Editorial Advisory Board
H. J. Freyn Dr. J. S. Unger
Barton R. Shover F. E. Kling

Editorial Advisory Board
Kenneth B. Lewis E. H. McClelland
C. H. Herty, Jr. F. F. Slick

Editor—DON N. WATKINS
Managing Editor—CHARLES LONGENECKER
Engineering Editor—J. R. MILLER

Volume XVI NOVEMBER, 1928 Number 11

CONTENTS

Iron and Steel Manufacturers Meet 1429
Steel Plant Executives Express Belief that Demand for Products Will be Maintained—Declare Present Prices Too Low

Present Status of Structural Steel Welding 1430
Pertinent Questions Regarding Welding and Bearing on the Use of Welding in Fabricated Steel Structures Are Here Clearly Answered—Importance of Quality of Welding Wire
By F. T. LLEWELLYN

Recent Observations on Some European Iron and Steel Conditions 1433
General Observations on the Conditions in Various Countries Is Followed by a Description of Steel Plants in Italy and Switzerland and of German Blast Furnaces
By C. A. MEISSNER

Steel Requirements of Aircraft Industry 1436
Present Development in the Art of Flying Has Brought New Problems to the Steel Industry—Value of Steels Required to be Considered Instead of Tonnage
By H. J. FRENCH

Steels Used by the Automotive Industry 1439
From the Steel Maker's Standpoint Automotive Steels Are Here Discussed in a Broad Way and with an Understanding of the Problems Involved in Their Utilization
By W. J. MacKENZIE

Relative Cost and Value of Fuels 1446
Data Here Given Comparing the Relative Value of Various Fuels Against Their Cost Brings Out Clearly the Advantages of Producer Gas in Open-Hearth and Heating Furnace Operation
By E. A.-W. JEFFERIES

Sheet Steel for Automobile Bodies 1449
A Review of the Various Methods Employed in Testing Sheet Steel—Ductility, Hardness and Tensile Tests Are Compared with the Results of Microscopical Examination
"AUTOSHEET"

Design and Operation of Strip Mills 1454
Description of Mills and Their Development Are Here Given with Information Concerning Production and Products—Furnaces and Devices for Charging and Drawing Billets
Translated by R. W. DEIMEL

The Power Plant—
Practical Points on Feed Water Treatment 1461
Various Methods of Treatment Are Reviewed Both with Regard to Results Attained and the Routine of Application—Operating Costs Discussed
By J. GUEST

Iron Ore 1427
Meeting Boosts Metallurgical Research 1444
Co-operation and Accident Prevention 1459
By M. H. STEARNS
With the Equipment Manufacturers 1466
Trade Publications 1469
Trade Notes 1470
News of the Plants 1473
Coming Meetings 1473
The Open Hearth 1474
The Steel Plant Roll Turner and Designer 1478
The Steel Plant Brick Mason 1481
Safety First in the Steel Plant 1488

Published the first of each month by Steel Publications Inc.
Main Office—Thaw Building, 108 Smithfield Street, Pittsburgh, Pa.

DON N. WATKINS, President D. S. WATKINS, Vice President M. M. ZEDER, Secy.-Treas.

EASTERN MANAGER
ROBERT E. POWELL
29 West Thirty-fourth Street
New York
Phone—Wisconsin 5459

WESTERN MANAGER
GEO. P. GRANT
105 West Monroe Street
Chicago, Ill.
Phone—Randolph 3264

Subscription Price:—In the United States, $2 per year; Canada, $2.50; all other countries, $3.50. Single Copy 25 cents.
Entered as second-class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

The Blast Furnace and Steel Plant

Vol. XVI PITTSBURGH, PA., NOVEMBER, 1928 No. 11

IRON ORE

By GEORGE P. WARDLEY
Joliet, Illinois

Thru the countless years of sleeping
Neath the coverlet of earth,
Dreaming, waiting, meditating,
Of the time of my rebirth;
When the science of a nation
Lifts the lid of mystery
And releases me with freedom
To fulfill my destiny.

Happy now am I to enter
Into fields of magic, such
As the genius of the masters
Have enabled me to touch;
Touch with happiness to many
Or with usefulness to all,
As I gaily meet my duties
Thru the day or nightly pall.

The wooden ships have drifted
On the tides of yesterday,
While the steeled greyhounds scamper
Thru the mist and flying spray,
And the monsters of my making
Keep the rails of commerce bright
As the fearless eagle Lindy
Skims thru clouded stormy night.

The rainbowed colored chariots
Whirl the people cross the plains
That were witness to the struggle
Of prairie schooner trains,
And the roaring streams of beauty
Tumbling down the mountain side,
Send their song of whirling power
Faster than the giants stride.

The mighty arms of Hercules
Are lengthening to the sky
And bringing thru the ethered air
Earth's tales from low and high,
Or pulsing from their finger tip
Thru storm and deepening fog
A message to a lonely watch
As he slowly checks his log.

The surgeon plies his instruments
With a steady skillful hand,
And the life a mother prayed for
Leaves the shadowed valley land
To walk again along with her
And answering her caress,
Reads the story in her shining eyes,
Of infinite tenderness.

So I touch the lives of many
With the thoughts of usefulness,
And if this were all my story,
Life would be all happiness;
But the passions of a people
Rise to heights beyond control,
Raging hatred, grim destruction,
Seems to be their chosen goal.

Then I mourn my awful power
If this be my destiny,
Loathe the magic of a science
That had ever set me free;
Curse the dreaming, meditating,
Of the time before my birth,
Pray for countless years of sleeping
Neath the coverlet of earth!

Iron and Steel Manufacturers Meet

Steel Plant Executives Express Belief that Demand for Products Will be Maintained—Declare Present Prices Too Low

LEADERS of the steel industry, in their speeches at the meeting of the American Iron and Steel Institute held in New York, October 6, were quite in accord in forecasting a continuation of the present prosperity. That the industry is in a healthy condition, and will continue so, was the unanimous opinion of all those who took part in the meeting.

Charles M. Schwab, the president of the Institute, as in his address at the last meeting, drew attention to elements in the conduct of business which he decried as detrimental to all manufacturers. Mr. Schwab suggested that there be no discrimination in the prices quoted different customers for the same product; he said: "For a manufacturer a considerable distance away to underbid the fair price offered by the nearby plant is obviously uneconomical and tends to indiscriminate price cutting and to cross-hauling, an unwise practice of our industry to which I referred at some length in my talk last May."

"Production capacity," Mr. Schwab stated, "should not be increased, for at present steel can be supplied in ample quantity to meet all requirements." In regard to supply and demand he remarked: "It is now a certainty that the year 1928 will establish a new record in volume of production for the steel industry of the country. Insofar as an increase in demand is the solution of our economic difficulties we are nearer to a proper relationship between supply and demand than we have been since the end of the war. This increase in demand has resulted, as should be expected, in a betterment in prices—virtually the first improvement that has occurred in five years. I hope and believe that there will be a still greater improvement in prices sufficient to afford to the industry a return upon its investment fairly comparable to that realized by other leading industries."

"Much has been done to increase the demand for steel by finding new fields in which it may be used advantageously, but much more can and should be done. An extension of the activities of research departments not only to make improvements in the quality of our products and in the methods of producing them, but also to discover new uses for them, is desirable. A closer co-operation between the producers of steel and our customers, promoting a better understanding of our customers' problems and resulting in our providing steel which will more perfectly meet their requirements will often prevent the customer from seeking substitutes for steel. In these and many other ways the demand for steel can be increased and thus help to restore permanently a proper balance between demand and supply. In this connection, however, let me remind you that this balance even if restored can quickly be upset and recurrence of the present unsatisfactory conditions in our industry brought about by an unwise and unnecessary increase in capacity."

Other speakers besides Mr. Schwab were Willis L. King, of the Jones & Laughlin Steel Corporation; Horace S. Wilkinson, of the Crucible Steel Company, and George M. Verity, of the American Rolling Mills Company. The speakers emphasized the fact that the manufacturers of steel do not receive an adequate return for their products, and that the profits are not in proportion to those obtained in the sale of other commodities.

At the morning and afternoon sessions seven papers were delivered; the subjects and the authors were: "An Acoustic Laboratory for the Testing of Music and Other Steel Wires," W. B. White, acoustic engineer, American Steel & Wire Company, Chicago, Ill.; "Uniformity, Continuity and Magnetic Testing," A. V. DeForest, research engineer, American Chain Company, Bridgeport, Conn.; "Steel Requirements of the Aircraft Industry," H. J. French, senior metallurgist, Bureau of Standards, Washington, D. C.; "Recent Observations of Some European Iron and Steel Conditions," C. A. Meissner, United States Steel Corporation, New York; "The Present Status of Structural Steel Welding," F. T. Llewellyn, president, American Welding Society, New York; "Steels Used by the Automotive Industry," W. J. MacKenzie, vice president, Interstate Iron & Steel Company, Chicago, Ill., and "Rust, Acid and Heat-Resisting Steels," Dr. W. H. Hatfield, Brown-Firth Research Laboratory, Sheffield, England.

The papers elicited considerable discussion. Mr. Paul H. Bilhuber, of Steinway & Sons, enlarged on various features in the paper presented by Mr. W. B. White. Others who took part in the discussions were: Mr. Elmer A. Sperry, of the Sperry Gyroscope Company; John F. Hardecker, of the United States Navy Yard; E. C. Smith, Central Alloy Steel Corporation; George H. Danforth, Jones & Laughlin Steel Corporation; Henry Wysor, Bethlehem Steel Company, and John A. Matthews, Crucible Steel Company.

Four of these papers will be published in this, and the December issue of Blast Furnace and Steel Plant.

The toastmaster at the banquet was Mr. Schwab. Mr. Myron C. Taylor, the first speaker, recognized in his remarks the service performed by the pioneers of the industry. He referred to the accomplishments of J. Pierpont Morgan, H. C. Frick, Andrew Carnegie and George F. Baker. Following Mr. Taylor, Dr. Harry Emerson Fosdick impressed upon his audience the necessity for a careful expenditure of the resources that are available in the United States. He referred to our natural resources which are being lavishly drawn upon.

Among the guests at the banquet was Dr. Hugo Eckener. After receiving a most hearty welcome he spoke briefly.

At the meeting of the board of directors of the institute, E. J. Buffington and George M. Verity were elected to fill the vacancies created by the death of Elbert H. Gary and Joseph G. Butler, Jr. Additional directors elected were E. T. Weir, Homer D. Williams, F. J. Griffiths and Elmer T. McCleary. Mr. Willis King was elected an honorary vice president of the institute upon his retirement as a director; T. M. Girdler will succeed Mr. King on the board of directors.

Present Status of Structural Steel Welding*

Pertinent Questions Regarding Welding and Bearing on the Use of Welding in Fabricated Steel Structures Are Here Clearly Answered—Importance of Quality of Welding Wire

By F. T. LLEWELLYN†

TWO and a half years ago, when the need of an authoritative committee to consider the welding of structural steel was being discussed, a prominent engineer, Mr. J. H. Edwards, outlined several questions whose satisfactory answer he thought must precede any general acceptance of fusion welding as a major tool by the structural industry. The questions may be summarized as follows:

1—Can standard grades of steel be satisfactorily welded?

2—What effect will the welding operation have on the base metals that are to be united?

3—Can methods of making welds by different processes be standardized?

4—Can values be fixed on some unit basis for the strength of the more usual types of welded joint?

5—Is there some way of determining the reliability of the completed weld?

6—Can the welding operations be done at a competitive cost?

Since the formulation of these questions considerable progress has been made in the art of welding. Many commercial structures have been erected by the welding process, involving fairly large tonnages of steel. Much attention has been given to laboratory investigation, microscopic, chemical and mechanical. There has been more research into the problems of welding within the past few years than had been given to other methods of fabrication throughout their entire period of use. It therefore seems timely to indicate to what extent Mr. Edward's pertinent questions are today capable of being answered, and such is the purpose of this paper.

The replies attempted are the observations of the writer, which may possibly be qualified when final report of the Structural Steel Welding Committee is ready. In supporting some of them he has borrowed from a remarkably lucid study on metal-arc welding by H. Dustin of the University of Brussels, published in the December, 1926, issue of "Revue Universelle Des Mines," Liege, Belgium. Professor Dustin's experience is in general agreement with that of investigators in this country.

The facts presented refer primarily to d.c. metal-arc welding. This limitation does not signify that other processes of welding are not suited to structural steel work. They may and doubtless would be entirely adequate, for they have been so found in other fields, but other processes have not been sufficiently developed in the structural field to furnish actual data from which conclusions can be drawn, whereas information as to the behavior of structural members united by the current metal-arc welding process is of considerable amount. This is the process, therefore, that will be generally referred to in the present paper under the brief term "welding." In view of the fact that much of the data on which our answers are based was secured in connection with the activities of the Structural Steel Welding Committee, already referred to, an outline of the work this body is now engaged upon is in order. The committee functions under the American Bureau of Welding, a board of research sponsored by the National Research Council and the American Welding Society. It includes representatives from the major engineering societies, the United States Bureau of Standards, the steel mills, the fabricating shops and the makers of welding equipment. It was organized in the fall of 1926 for the purpose of obtaining reliable information upon which safe unit working stresses in the design of welded structures could be based.

The committee first studied all available literature giving results of tests on welded joints from which unit working values could be deduced. This information was summarized in the November, 1927, issue of the Journal of the American Welding Society. It was found that the data were insufficient to form an authoritative basis for the establishment of standard working stress values. The committee therefore decided that further tests were needed that would:

1—Confirm or qualify previous results by the use of a larger number of specimens and a more uniform system of testing.

2—Supplement the scope of previous data by tests on additional forms of joint.

3—Determine what degree of uniformity in commercial welding may be expected.

The program now being carried out covers 57 forms of joint in 191 sizes welded by the gas or the arc process. The specimens are of elemental type and embrace fillet welds of lap and tee form, end and edge butt welds, and special joints. Single and double lines of weld, normal, parallel and diagonal to direction of stress, continuous and intermittent, are specified. Entire members may be considered later.

Specimens are to be subjected to static tests for ultimate strength, yield point and ductility. These may be supplemented by dynamic and other special tests. The general aim has been to proportion specimens so that they will fail in the joint and thus indicate unit weld strength, but for check purposes a few types are included that will probably fail in the base metal.

In order to determine what degree of uniformity may be expected in commercial practice, multiple specimens of each type and size are scheduled whose preparation is being distributed among some 36 representative fabricating shops throughout the United States and Canada. Welding operations will be governed by uniform procedure and inspection regulations. An important part of the program will be the keeping of record as to the sufficiency of these regulations.

---

*Paper before the American Iron and Steel Institute, New York, October 26, 1928.

†President, American Welding Society, New York City.

The steel needed for the program specimens (nearly 2,000 in number) has been donated by three rolling mills. Offers to do the work of preparing specimens have been received from a larger number of shops than can be accommodated. Co-operation in the testing of specimens has been tendered by many laboratories, including the United States Bureau of Standards. Special mention should be made of Professor Peter Gillespie who, under the auspices of the University of Toronto, has made several hundred pilot tests for the guidance of the committee.

With this background we will now take up the questions previously recited.

Can Standard Grades of Steel be Satisfactorily Welded?

The unqualified answer is "Yes"! By "standard" is meant those grades of structural steel that are commonly used for bridges or buildings, conforming to specifications A-7 or A-9 of the American Society for Testing Materials. Silicon steel also seems to be well suited to welding, and high carbon steel and special alloys have been satisfactorily welded, but these products have not been investigated sufficiently to warrant an unqualified statement regarding their behavior when welded.

The weldability of standard grades, on the other hand, is established by thousands of tests. Perhaps its best confirmation is the well-known fact that important commercial structures, in every section of the country, framed with members of standard grade steel, have been and are now being welded with entire satisfaction. (See tables E and F.) Certain less satisfactory results reported several years ago, in the welding of thin to very thick metal, have been remedied by directing the arc at the thick metal so as to secure the uniform fusion of both parts.

Closely allied to the matter of grades of base metal steel is that of grades of welding wire. Apparently the latter is the more important. As used in the process we are considering, welding wire play a dual role. It serves both as electrode and as filler rod. Its use as electrode might connect it with answers 3 and 5, but its use as filler rod makes it more convenient to summarize its functions here. Dustin says "the wire used engraves its indelible signature upon the weld," and "the feature that outweighs everything else is the great importance of a proper selection of welding wire." The most skillful technique can never make a sound weld if the wire be not sound. The writer will not attempt here to classify the many varieties of wire that are now on the market, but he would go on record to the effect that mere economy in first cost is a mistaken basis on which to judge welding wire.

The conclusions presented in this paper are predicated on the use of bare wire of a grade equal to classes E1A (maximum carbon 0.06) or E1B (carbon 0.13 to 0.18) of the American Welding Society, as applied to mild steel base metal (maximum carbon 0.30) conforming to A. S. T. M. specifications A-7 or A-9.

As used here the word "bare" is comparative, for no wire ordinarily employed for welding is absolutely bare. If it were, it would not make a weld. The process of wire-drawing requires a lubricant of lime or some other alkali, and enough of this coating is retained on the surface of the finished wire to furnish the slagging flux essential to the soundness of the deposited weld metal. It may be surmised that, if the wire-drawing process had not required such a convenient flux, the invention of fusion welding might have been set back many years.

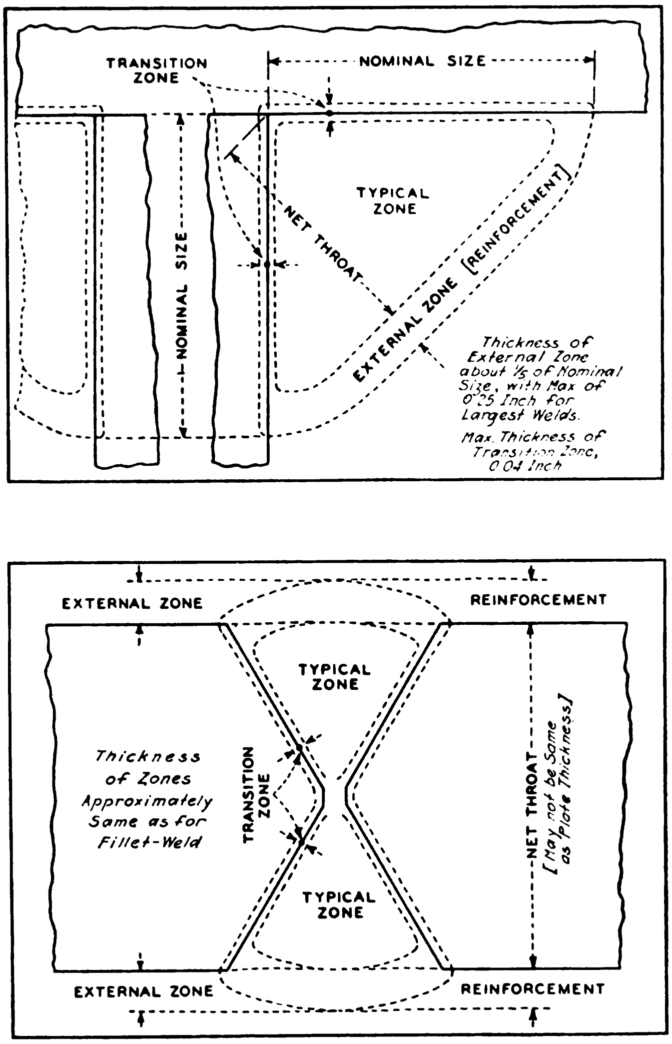

TRANSITION ZONE
NOMINAL SIZE
NOMINAL SIZE
TYPICAL ZONE
NET THROAT
EXTERNAL ZONE [REINFORCEMENT]
Thickness of External Zone about 1/5 of Nominal Size, with Max of 0.25 Inch for Largest Welds.
Max. Thickness of Transition Zone, 0.04 Inch
EXTERNAL ZONE
REINFORCEMENT
TYPICAL ZONE
Thickness of Zones Approximately Same as for Fillet-Weld
TRANSITION ZONE
TYPICAL ZONE
NET THROAT
[May not be Same as Plate Thickness]
EXTERNAL ZONE
REINFORCEMENT

FIG. 1A (upper)—Diagrammatic section through fillet-weld.
FIG. 1B (lower)—Diagrammatic section through butt-weld.

As applied to welding, therefore, the term "bare" refers to wire as it comes from the mill, in contrast with wire that is subsequently given an additional coating or a covering. The term "coated" refers to wire that has received a specially applied fluxing coat (generally a silicate) of considerable amount. The term "covered" refers to wire enveloped by a fabric (frequently of asbestos) which either serves to retain the coating between it and the wire metal core, or which has itself been impregnated with a suitable flux. Dustin states that a coating has three functions:

1—To combine with the oxides of the base metal.

2—To protect the molten or white-hot metal with a de-oxidizing slag.

3—To serve as a vehicle for the introduction into the weld of special elements (carbon, nickel, manganese, chrome, etc.) in case it is desired to modify properties. By providing a suitable coating we can actually deposit a steel of any predetermined composition, even stainless or high-speed tool steel.

What Effect Will the Welding Operation Have on the Base Metals that Are to be United?

The answer is that it will have no harmful effect—certainly not if the base metal is mild steel. This feature can be presented more clearly with the aid of diagrams drawn to an enlarged scale. Figs. 1-A and 1-B show ideal sections through fillet and double-V butt welds, respectively. In the diagrams the contact surface of the original base metal is shown by full lines and the extent of the weld by broken lines. Referring to the weld as a whole, it has been well said that welding wire normally deposits a soft steel which is purer than its source. Dustin states that if coated mild steel wire is used the manganese is affected but little, silicon disappears almost completely, phosphorus is somewhat and sulphur greatly reduced, while carbon remains unchanged at from 0.10 to 0.14 per cent. If bare wire is used the manganese tends to disappear, sulphur may remain, and carbon be reduced to less than 0.05 per cent.

If the base metal is mild steel, regardless of grade of wire or welding conditions, the weld is found to contain three zones, which always occur in the same sequence and with constant characteristics:

1—A transition zone at the contact surface of weld and base metal.

2—A typical zone in the body of the weld.

3—An external zone in the outside layer of the weld.

At this time we will consider in detail only the transition zone adjoining the base metal. In extent this zone never attains a thickness of one millimeter, and only from two to three-tenths of its thickness are occupied by the portion in which there is interpenetration of base and weld metal. This zone is sometimes invaded by impurities from the base metal, but no impurity in the weld metal ever penetrates beyond the transition zone into the base metal. These facts are established by many microscopic analyses. Therefore any effect of the welding operation on the base metal beyond must be merely a thermal one. We will consider such thermal effect after giving a summary of the characteristics of the transition zone itself.

Micrographs show that the transition from base to weld metal is marked by a reduction in grain-size, that is to say by a refining effect, but it is also sometimes accompanied by more slag inclusions than occur in other portions of the weld. In welds properly made, with good wire, these inclusions are too minute to be visible to the naked eye and should not be considered as serious defects. They do mean, however, that the metal in this zone is not always as strong (per unit) as that in the body of the weld, by an amount that never seems to exceed 30 per cent and is generally very much less.

This weaker zone should be, and in current practice is, compensated for by providing contact surfaces that are greater than the critical throat dimensions. In the case of important butt welds, additional area is secured by beveling the edges of the base metal, thereby giving to the weld a V form. In the case of triangular fillet welds no such preparation is needed, for the reason that the ratio of the leg of an isosceles right triangle to the normal to its hypoteneuse is happily greater than is required. This is one reason why a fillet form of weld is to be preferred in most structural work. It eliminates the cost of beveling.

Reverting now to the thermal effect of the welding operation on the adjacent base metal, it should be pointed out that the heat is conducted across a much narrower belt than is commonly supposed. The writer has frequently touched base metal within four inches of a progressing weld, without any discomfort. While the temperature of the arc is high, its duration at any point is brief. But whatever the extent of the heat, it is proper to investigate its results.

In tests on welded joints, rupture frequently occurs fairly close to the weld. It would seem as if the effect of welding was to transfer the locus of rupture to a point on the base metal that is one or two times its thickness away. A hasty conclusion might be that the effect of welding is to cause brittleness in the base metal near the weld. The contrary is indicated by some of Dustin's experiments.

TABLE A—Effect of Weld on Base Metal (Dustin).

	Averages of three specimens machined to 0.79-inch diameter			Neat weld metal, deposited from wire-T (Average of table C)
	Unwelded			
Properties tested	Untreated	Annealed 10 minutes at 900° C.	Welded with T-metal	
Ultimate tensile strength in kips* per sq. inch...	67.2	50.7	53.4	56.7
Per cent elongation measured on 7.9 inches for unwelded specimens, and on 3.9 inches for neat weld metal........	12.0	32.0		16.8

*A kip is 1,000 pounds.

He took three merchant steel bars, welded portions of them together, and pulled them in a tension testing machine. All three specimens necked at points straddling the weld and then broke, about half an inch away from the weld, under stresses of 53.5, 53.5 and 53.2 kips per square inch. (A kip is 1,000 lb.) Their average (53.4 kips) is tabulated in table A. Their elongation was not reported. It would be difficult to measure elongation over portions of the base metal alone sufficiently close to the weld to give a significant result.

He used other portions of the same bars to make two sets of plain unwelded specimens. One set was tested without any treatment, and the other set was annealed prior to testing. The results are given in table A, which also shows the average properties of the weld metal used, as tabulated in table C.

These tests indicate that the effect of welding was to reduce the ultimate strength of the adjacent base metal by 20 per cent, accompanied, however, by an increase in ductility as evidenced by the necking. If fabricated by a method requiring punching, the net area of a plate with usual hole spacing would be reduced still more (33 per cent) with no increase in ductility.

What happens in the process of welding? The base metal is raised to a bright red color over a belt whose width varies with its thickness and with the volume of the weld. It then cools freely in the air. This means that near the weld the piece undergoes precisely the same treatment as would normalize mild steel.

(To be continued)

Recent Observations on Some European Iron and Steel Conditions*

General Observations on the Conditions in Various Countries Is Followed by a Description of Steel Plants in Italy and Switzerland and of German Blast Furnaces

By C. A. MEISSNER†‡

HAVING visited Italy, France, Switzerland, Germany and Luxemburg in the spring of 1928 it enables me to place before you a few observations of a general and technical nature that would give a viewpoint of how conditions appeared to the writer at that time.

The first impression is one of quite general recovery and improvement in European living conditions and certainly in many respects improvement in industrial conditions.

An important feature was the preparation for building new highways and the improvement of their existing roads. This improvement in roads is very much in evidence all through Western Europe and is perhaps of greater importance than is first realized, not only from a standpoint of living and commercial transportation conditions, but ultimately from an industrial standpoint.

It is surprising to see the number of bicycles used everywhere by men, women and children in their general and industrial work. Next in line are the motorcycles. Third in line are the automobiles and it was rather astonishing to see the number of European automobiles in use in the cities, not only for pleasure, but also for commercial and industrial purposes. Knowing what the automobile business means to the United States, it would seem that Europe is following along the lines of our country in this respect.

Another step that was of interest was the utilization of water power for electrical purposes of all kinds, but particularly for operating railroads. In Italy we saw comparatively few coal-fired locomotives and every effort is being made to increase water-power installations and the uses of electricity. The snow-clad mountains of the Apennines give them a fairly constant annual water supply and they appear to be using it with great intelligence and foresight.

While speaking of the railroads, it is interesting to note that about 50 per cent of all rail ties in Germany are made of steel and it is proposed by the German Government Railway to increase this proportion to about 66 per cent of the total in the near future. Great attention is paid to the manufacture of their steel rails and fittings, and their road beds admit in many cases of heavy trains running 50 to 60 miles per hour.

There are through trains of steel construction, commodious and comfortable, and it may be of some interest to know that the German Government has recently established several stations for varnishing or painting steel cars by a spray which is said to give very excellent and permanent results.

The general appearance of the country would indicate that the farmers are in a very fair condition, as shown by intensive truck gardening and very general cultivation of fields all through Western Europe, with the exception of those in the vicinity of the old war zone adjacent to Paris where there are still many ragged areas of land showing trenches and shell holes.

Cleanliness and fair sanitary conditions in the towns and villages were very noticeable. A general complaint is that the price of food is still too high.

The object of this trip was not primarily to visit many steel plants, but to try to obtain answers to questions of particular interest to some of us here on subjects which have recently been discussed and are of direct interest to our blast furnace and open-hearth men.

Italy

In Italy we visited the Bagnoli plant, at Naples, and the Piombino works, at Piombino, both plants being owned by the "Ilva" Alti Forni e Acciaierie d' Italia; we also visited the Terni Steel Plant at Terni, Italy. These are the three most prominent iron and steel plants in Italy. They are said to be under one general controlling head and to receive subsidies from the Italian Government.

An interesting feature in Italy, and really through a great part of Europe, is the intensive use of cable bucket systems carrying materials from the docks and stock piles to the plants, and also in many cases long distance cable systems were seen for mineral, lumber and other materials.

Bagnoli Plant, Naples, Italy

The plant consists of two 400-ton blast furnaces and one smaller one, five 60-ton basic open-hearth furnaces, a rail, structural, billet and bar mill. Coke is supplied from 64 old-type Koppers ovens. The blast furnaces at this plant are successively being rebuilt along modern American lines. They use ore shipped from company mines on the Island of Elba, Etruscan slag from ancient works near Piombino containing 45 to 48 per cent iron, and pyrites clinker containing 61 per cent iron and .05 per cent sulphur. No scrap is charged. The slag is granulated for use in a local cement plant.

The coke, made from Durham and Westphalian coals, is large, blocky and irregular. Italy has no coking coal; before the war Pocahontas coal was imported, but it is now too expensive. Excess by-product gas is burned under boilers. Coke consumption was about 1980 lbs. per ton of iron.

---

*Paper read before the American Iron and Steel Institute, New York, October 26, 1928.

†Chairman, Coke, Blast Furnace and Open-Hearth Committees, United States Steel Corporation, New York.

‡Acknowledgment is made of the faithful collaboration in obtaining these data of James A. Meissner, superintendent, Bessemer blast furnaces, Tennessee Coal, Iron and Railroad Company, who accompanied me on this trip. Appreciation is expressed for the many courtesies extended and information given by the officials at the various European plants visited and particularly by Dr. Ing. O. Petersen and his staff in Duesseldorf.

Each blast furnace has four stoves, using semi-cleaned gas. The blast temperature was 1300 deg. F. and top temperature 210 deg. F. Gas for the engine room went through Zschocke centrifugals for use in gas blowing engines, and several gas engine electric generators.

The open-hearth plant had three furnaces operating, using about 30 per cent hot metal and 70 per cent scrap in the charge. Producer gas made from lignite and coal was the fuel. The soaking pits were also heated with producer gas.

Piombino Works, Piombino, Italy

Blast Furnaces—There are three blast furnaces at this plant; two operating. The third was being rebuilt, with lines following American practice.

Dimensions of the large furnaces are as follows:

Hearth diameter	16 ft. 5 in.
Bosh diameter	20 ft. 4¼ in.
Top diameter	15 ft. 9 in.
Bell diameter	9 ft. 10 in.
Inwall angle	86 deg. 0 min.
Bosh angle	79 deg. 50 min.
Bosh height	9 ft. 10 in.
Total height	72 ft. 2¾ in.
Inwall lining	35½ in.
Bosh lining	19¾ in.
Hearth lining	31½ in.

The stacks are of usual European type, fire brick reinforced with bands without any shell.

Boshes are petticoat type with spray cooling, lined with fire brick made at Livorno, of the following analysis: Al_2O_3, 44 per cent; SiO_2, 55 per cent; FeO, 1 per cent.

Hearth jackets are steel plate with spray cooling, using great quantities of water. They are completely exposed, the columns resting on the same foundation as the hearth. Bottom blocks lie 78¾ in. thick, of same fire brick as used in the bosh and hearth lining.

Tops are single bell, central gas offtake type, with distributing tube below bell. Filling is done with cable buckets. These cable buckets are used for transferring ore from ships to storage, carrying coke from ovens to furnaces, and are very well liked.

Raw Materials—Hematite and specular magnetite and brown ores from Elba, lumpy and fine. Sinter from pyrites mixed with flue dust. Manganese slag from electric ferro-manganese furnaces. Etruscan slag sometimes used, from Populonia. Limestone (54 per cent Ca) very irregular in size. Coke, large and blocky.

Operating Details—Large furnace had a production of 300 tons per day, coke consumption ranged from 2090 to 2200 lbs. per ton. Wind blown about 28,250 cu. ft. per min. Blast pressure 15¾ in. of mercury. Top pressure 4 in. of water. Hot blast 1290 to 1470 deg. F.

Slag was all granulated, analysis as follows: SiO_2, 33 to 35 per cent; Al_2O_3, 13 per cent; CaO, 44 per cent; MgO, 2 to 3 per cent.

Stove equipment consists of four for each furnace. They are 19 ft. 8⅜ in. in diameter and 98 ft. 6 in. high, with 32,280 sq. ft. heating surface each.

The engine room contains the following equipment:

Blowing—
1 Mulhouse, 1500 hp., horizontal, 2-cylinder steam engine.
1 Mulhouse, 2500 hp., horizontal, 2-cylinder, 670 cu. ft. per revolution, steam engine.
2 Mulhouse, 1500-hp. gas engines, 388 cu. ft. per revolution and 14.7 lbs. per sq. in. maximum pressure.

Electric Generators—
2 Brown-Boveri, 1500-kw. turbo-generators.
1 Stall, 4800-kw. turbo-generator.
1 Mulhouse, 1200-kw. gas engine.
A.c. at 3000 volts is generated.

Gas Cleaning—Blast-furnace gas is passed through Zchocke and Theissen washers to a storage tank. It is cleaned to .05 grain per cu. ft.

Piombino Coke Works—This plant consists of the following:

28 Old Belgian ovens, no by-product recovery, 3.5 tons each.
44 Otto ovens, recovery of benzol and ammonium sulphate, 5 tons each.
66 Leonard ovens, 4 tons each.

Becker type coke ovens are in course of construction.

Ammonium sulphate production is 22 lbs. per ton of coke. It looks very good and is all sold in Italy.

All coke is screened, over 1½ in. goes to the furnace. We understand they have a good market for domestic coke.

Coals used for present coking are Westphalian and Durham, giving a large block coke.

Electric Ferro-Manganese Furnaces—Three small, single-phase electric furnaces have a production of 16 tons per day of 80 per cent ferro-manganese. They use Caucasian and Indian sinter, the latter containing 50 per cent Mn and 5 per cent Fe, and mix with it coke dust and lime.

Current was 23,000 amperes and voltage, 41. Called the direct process.

Open-Hearth Furnaces — This plant comprises five 50 to 60-ton basic furnaces, two of which are operating. Charges usually 65 per cent hot pig and 35 per cent scrap. Limonite ore from Elba is used, and burnt lime. Five to six hours are required for a heat. 45 per cent ferro-silicon is used.

The 300-ton tar-heated mixer requires about 3 tons of tar per day.

Brick-lined hot tops are used for rail steel ingots.

Open-hearth fuel is producer gas made in Stein Shafman producers, from lignite. The lignite mines are at Grosseto, 24 miles distant, where 300 tons per day are mined. Analysis of lignite is as follows: Ash, 15 per cent; volatile, 45 per cent; moisture, 12 per cent; fixed carbon, 28 per cent.

Gas made from lignite has following analysis: CO_2, 4 to 5 per cent; CO, 25 to 30 per cent; CH_4, 4 to 5 per cent; H_2, 10 per cent; O_2, 2 to 4 per cent; N_2, difference.

A reserve of Scotch coal is kept on hand. Fuel requirements are about 770 lbs. of lignite, or 616 lbs. of coal per ton of steel made.

Mills—Sixty producer gas-fired soaking pits are available. Fuel consumption for heating ingots is 132 lbs. of lignite per ton.

Ingot molds are 22 in. square and 5 ft. 8 in. high. Ingots weigh from 3 to 4 tons.

Blooming mill is 39⅜ in. reversible, driven by 8000-hp. steam engine. Blooms are sheared by electric shear.

Rail mill is driven by the same engine as blooming mill, on the opposite side from bloomer. Rail mill capacity is 400 tons per day. Street car rails up to 110.5 lbs. per yard are rolled. Railroad rails up to 100.5 lbs. per yard are rolled, with .45 per cent carbon and 1.10 Mn for heavy sections. Rail lengths are 39 ft. 3¾ in and 54 ft. 11¼ in. "I" beams up to 15¾ in. are rolled. All rails are put through roller straightener though additional hand straightening is sometimes required on the ends. They find the roller straightener very satisfactory.

Near Piombino we also visited old workings of the Etruscan miners for zinc and lead, in the smelting of which they left behind a slag containing 45 to 50 per cent of iron. These old slag dumps have been opened up and this iron bearing slag is used at the Bagnoli plant and also at times at the Piombino works. The remainder of their ores are received from Elba.

Limestone, of course, is available anywhere in Italy. The spallings from their best Sienna and Carrara marbles are used for blast furnace flux.

The Piombino plant is sintering its flue dust.

Terni Steel Plant, Terni, Italy

At the Terni Steel Plant they have no blast furnaces. This is largely a government plant for railroad equipment, guns, armor plate, etc.

The steel plant consists of two 40-ton basic and two 30-ton acid open-hearth furnaces, burning producer gas made from English coal and local lignite.

Lignite is found in large quantities in Tuscany, some 50,000,000 tons being the estimated reserve. It lies in a mountainous region, in two veins, each some 21 ft. thick where now mined. Production is 450 tons per day and it is used for lighting gas as well as producer gas. It is light weight and not a very good material.

The steel was cast in large ingots for heavy forgings, such as gun barrels, and small 3⅛ x 4¾ in. ingots for direct rolling in the bar mill without use of blooming mill. Large slab ingots for armor plate, etc., special molds for locomotive tires, and a steel foundry were also supplied from these open hearths.

The forge shop was well equipped with large furnaces, revolving or circular cranes, and heavy steam hammers for gun barrel ingots, etc.

The plate mill had quite a large supply of nickel-chrome armor plate on hand, and was not running.

They also have a locomotive tire plant.

The bar mill, four years old, is semi-continuous, and rolls small ingots instead of billets. It is driven by hydraulic turbines, made in the plant, using water at 270 lbs. per sq. in. pressure, and operating through reduction gears.

All of the older mills in the plant are hydraulic turbine driven, water coming from a reservoir above Terni Falls, where the new hydro-electric station is being built.

The strip, sheet and tinplate mills had been in operation only a few months, appear to be of good design and are housed in large, reinforced concrete buildings. They are electric motor driven, and were rolling about 80 tons of tinplate per week. The percentage of seconds in the tinplate mill was about 30 per cent.

Brown-Boveri Company, Baden, Switzerland

This company has a very well arranged, modern plant, with manufacturing facilities for turbines of all sizes and for all purposes, electric generators, motors, transformers and a wide variety of miscellaneous electrical equipment.

Among the interesting developments noted was their large turbo-blower with steam inlet on both sides for the purpose of eliminating end thrust. On light loads only one steam inlet is used, the steam from that side being bypassed to the opposite inlet, going through the other side and then to the condenser. Blowers of this type have recently been installed at Knutange, France, and Hattingen, Germany.

Two 90,000 cu. ft. per min. turbo-blowers were on order for Krupp Company's new blast furnace plant at Essen, Germany.

A 160,000-kw. turbo-generator for the Hell Gate Station, New York, was in course of construction. It is a double unit, with high-pressure turbine driving one 80,000-kw. generator, and low-pressure turbine driving another 80,000-kw. generator in parallel. The high-pressure turbine has triple steam inlet, the second and third valves letting steam into successive intermediate steam wheels to carry peak loads. Correspondingly, the low-pressure turbine has triple outlet, successively drawing steam off from intermediate wheels as more steam comes from the high-pressure side. This excess low-pressure steam is used to heat the feed water, so that no heat is lost from the system and the condensers are not overloaded.

They tried to stamp the blades for this machine, but could not get accurate surfaces, so all blades were being milled from small forgings and finished by hand. The steam wheels are mounted on chrome nickel, circular, cup-shaped springs pressed between hub of wheel (in a recess machined for them) and shaft, to eliminate loosening of wheels when the machine is cold and steam expands the wheels before the shaft gets warm.

Elektron metal, composed of 95 per cent magnesium and 4 to 5 per cent aluminum, is used for the large generator ventilating fans. This metal, while not as strong as duralumin, has but two-thirds the specific gravity, or 1.86. Each fan has a capacity of 2500 cu. ft. per sec. and is reinforced with steel bands to get the required strength.

Another interesting development was in the gear reduction drives for high speeds. Herringbone gears were giving trouble, because the accurate machining of both sides was difficult, so they now use spiral gears with a thrust collar on the pinion bearing directly on the side of the gear. They claim that due to the slightly conical shape of this thrust collar, running in oil, the wear is negligible.

The Brown-Boveri turbo-blower recently installed at Edgar-Thomson Works of the Carnegie Steel Company is operating satisfactorily.

In this connection it is interesting to note the tendency all over Europe, just as it is with us, to go to the use of turbines for new construction or replacement of old steam or even gas engines. The lower construction cost and the lower operating cost, when they can have high steam temperatures and pressures, to-

(Continued on page 1445)

Steel Requirements of Aircraft Industry*

Present Development in the Art of Flying Has Brought New Problems to the Steel Industry—Value of Steels Required to be Considered Instead of Tonnage

By H. J. FRENCH†

IT is now almost exactly twenty-five years since the Wrights first flew in a power-propelled heavier-than-air machine at Kitty Hawk, N. C. This demonstration that man was able to fly has been followed by a succession of astonishing developments until today air travel is an accepted method of transportation for both men and materials, and only transoceanic flights create much special comment.

For the first 15 years, or until the end of the World War, wood and fabric were the principal materials of construction for aircraft. Little steel was used except in the form of wire and in the power plant. Since the armistice in November 1918, metals, including steels, have become more important and have been applied successfully in the construction of practically all of the important parts of aircraft.

With the present rapid development of commercial aviation and the increasing use of metals in construction, it is, perhaps, timely to inquire what the aircraft industry may mean to the steel manufacturer with respect to both the tonnage and the character of the steels required.

The answer to this question necessarily must be predicated upon a forecast of the growth of the aircraft industry, the trend of aircraft design and future metallurgical developments. No one can make such predictions with any degree of accuracy and in the aircraft industry, where today's practice may be obsolete tomorrow, speculation is even more hazardous. Nevertheless, history and present practice throw some light upon the subject and should give an indication of the character of the demands which may be expected by the steel industry.

Production Aspects

Recent rapid growth of the aircraft industry may be illustrated by data given in a report of the Aeronautics Branch of the U. S. Department of Commerce.‡

> In aviation the industry is in the position of being far behind on orders. The production of aircraft during the calendar year, 1927, exceeded the 1926 output by more than 50 per cent. The civilian-owned planes in the United States now total over 4,000. There are more than 900 firms now engaged in aeronautics. Of these, about 90 lay claim to manufacturing aircraft. The aeronautic engine manufacturers total more than a dozen.
>
> During the calendar year, 1927, the aircraft manufacturing proper produced 1828 planes valued at $14,131,225. These figures represent increases of 54 per cent and 59 per cent, respectively, as compared with 1926. Military service absorbed 616 of these in 1927 and 63 were exported, leaving 1149 available for civil consumption.

It is now conservatively estimated by some members of the department that the production in the calendar year, 1928, will exceed 7000 planes, which would be an increase of over 380 per cent in one year. Over 10,000 engines should be built in the same period, provided the required expansion of manufacturing facilities can be completed. Already one manufacturer is producing around 160 engines per month and is planning for increased production.

It is interesting to note that today, 25 years after what may be called the birth of the industry, "the air-ways of the world show a greater mileage than did the railroads on their silver anniversary."

	Miles
United States—	
1927 Airways	8,556
1850 Railways	9,021
Europe—	
1927 Airways	31,137
1850 Railways	14,217
Germany—	
1927 Airways	11,003
1850 Railways	3,637
France—	
1927 Airways	7,419
1850 Railways	1,714
British Isles—	
1927 Airways	1,195
1850 Railways	6,621
Italy—	
1927 Airways	1,390
1850 Railways	265
Sweden—	
1927 Airways	992
1850 Railways	......
Denmark—	
1927 Airways	595
1850 Railways	20
Holland—	
1927 Airways	1,695
1850 Railways	110

Mileage comparison of airways and railroads on their respective silver anniversaries. Taken from Aeronautics Bulletin No. 1 of the Aeronautics Branch of the U. S. Department of Commerce, March 15, 1928.

Nevertheless, the tonnage requirements for steels used in actual flying equipment should remain a small part of the total production in the steel industry, even with astonishing increases in aircraft production. The reason for this is obvious since one object always in view is to keep down the dead weight of flying equipment. Further light is thrown on this subject by considering the demands of the automotive industry. Its products, which are built largely from steels, required only about 15 per cent of the total steel production in the calendar year, 1927.

While the tonnage requirements for steels used in the construction of actual flying equipment will probably remain small, quality steels are used, whose value per unit of weight is relatively high. If the value of these steels is considered in place of the tonnage required, a somewhat brighter picture is obtained of the probable demands upon the steel manufacturer.

---

*Paper read before the American Iron and Steel Institute, New York, October 26, 1928.

†Senior metallurgist, Bureau of Standards, Washington, D. C.

‡Aeronautics Bulletin No. 1, of the United States Department of Commerce, government printing office, March 15, 1928.

The business secured during the first seven months of 1928 from the aircraft industry has led one steel manufacturer to the conclusion that the demand during the calendar year, 1929, will be not less than 1500 tons of alloy steels for engine parts, 3000 tons of alloy steel for tubing, 100 tons of alloy steel for bearings and 50 tons of alloy steel sheet and strip. The total is not far from 5000 tons for the year with a market value in the neighborhood of $1,000,000. These estimates are especially significant when it is realized that the aircraft industry is still in its infancy and that steels are only one of the principal materials of construction.

The development of commercial aviation will also require expansion in airway and airport equipment including the construction of airway towers, hangars and other bulidings at airports. Such equipment will eventually require a considerable amount of ordinary structural shapes and also commercial sheets in various forms. Expansion of manufacturing facilities will require machine tool equipment and add to the demands for tool and die steels. It would therefore seem that the aircraft industry will need a variety of commercial and quality steels and there should be some measure of attractiveness to the business which will eventually come to the steel industry.

General Technical Requirements

In discussing the general technical requirements for steels used in the aircraft industry a three-fold division may be made, as follows: (1) Steels which do not form part of the actual flying equipment, such as tool and die steels for manufacturing purposes and steels used in the construction of airway and airport equipment, such as beacon towers, hangars, etc.; (2) steels for aircraft power plants; and (3) steels used in the aircraft structure, such as fuselage, wings, etc.

The technical requirements for the steels in the first group are similar to the requirements in other industries. The characteristics of these steels are generally well known and no special comments are needed here. The largest portion of the steels in groups 2 and 3 must meet special requirements, and it is to these that attention will be directed. Certain problems are common to both groups and will be considered first.

There are four general requirements for steels used in the construction of actual flying equipment. The steels should have (1) high strength per unit of weight to permit low dead weight of the aircraft; (2) high quality to insure reliability and satisfactory performance; (3) ease of fabrication; and (4) the ability, in individual cases, to meet special performance requirements.

Another factor, maintenance, may come into play in selecting steels for certain parts of construction. For example, it may be possible to sacrifice some degree of resistance to corrosion if the character and location of the parts and the conditions under which the aircraft are used will permit easy and periodic inspection and adequate servicing to prevent corrosion.

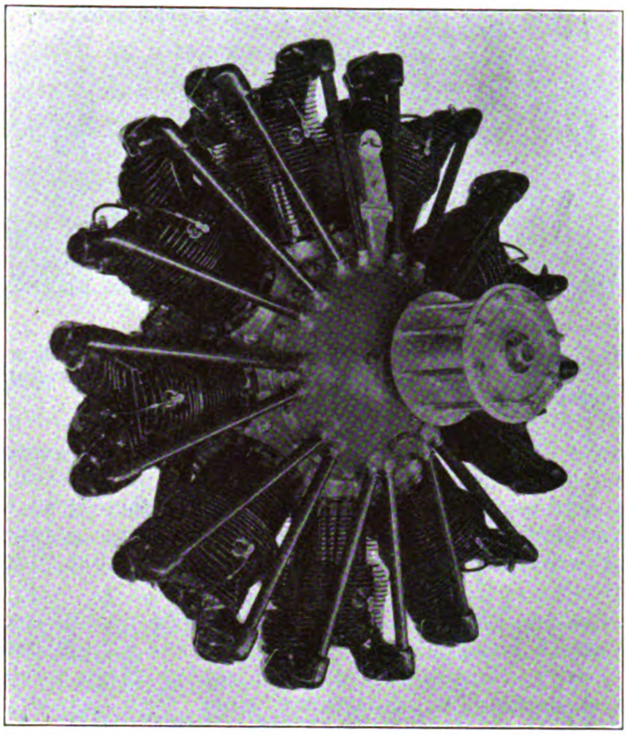


FIG. 1—The "Wasp" air-cooled aviation engine, rated at 525 hp. at 1,900 r.p.m. Courtesy of Pratt & Whitney Aircraft Company, Hartford, Conn.

Strength-weight factors — As shown in Table A, hard drawn wire has the highest strength per unit of weight of any of the commonly used materials of construction. The strength-weight factors of heat-treated alloy steels, such as are used widely in the automotive industry, are about the same as those of some of the aluminum alloys, such as duralumin, and the present magnesium base alloys. However, the two latter groups have a higher bulk modulus. This means that for equal weight and strength the aluminum alloy parts will have a greater thickness and therefore have

TABLE A

Strength-Weight Factors and Elastic Moduli of Materials Used or Which Give Promise for Aircraft Construction.
(Approximate Values)

Materials	Elastic* moduli, 1,000,000 lb. per sq. in.	Strength* lb. per sq. in.	Specific gravity	Strength per unit of weight divided by 1000
Wrought Metals—				
Music wire, 1/16 in. diameter	27 – 30	325,000	7.85	42
Structural alloy steel, heat treated	27 – 30	100,000 –200,000	7.85	13 – 25
High Ni-Cr corrosion resistant steels ...	27 – 30	100,000 –150,000	7.85	13 – 19
Duralumin (4 Cu, 0.5 Mg, 0.5 Mn, 0.25 Si, balance Al)	10	55,000	2.85	19
Magnesium alloy (4 Al, 0.4 Mn, bal'ce Mg)	5 – 6	35,000 – 45,000	1.77	23
Mild steel, normalized	27 – 30	55,000	7.85	7
Aluminum, annealed ..	10	12	2.7	4.4
Woods (Dry state)—				
Balsa	....	2,200	0.12	18
Douglas fir	1.4 – 2.2	7,000 – 10,000	0.54	15
Spruce	1.0 – 1.6	4,000 – 6,000	0.43	11
White oak	1.7	6,000 – 7,500	0.74	9

*In tension for metals, in compression for wood.

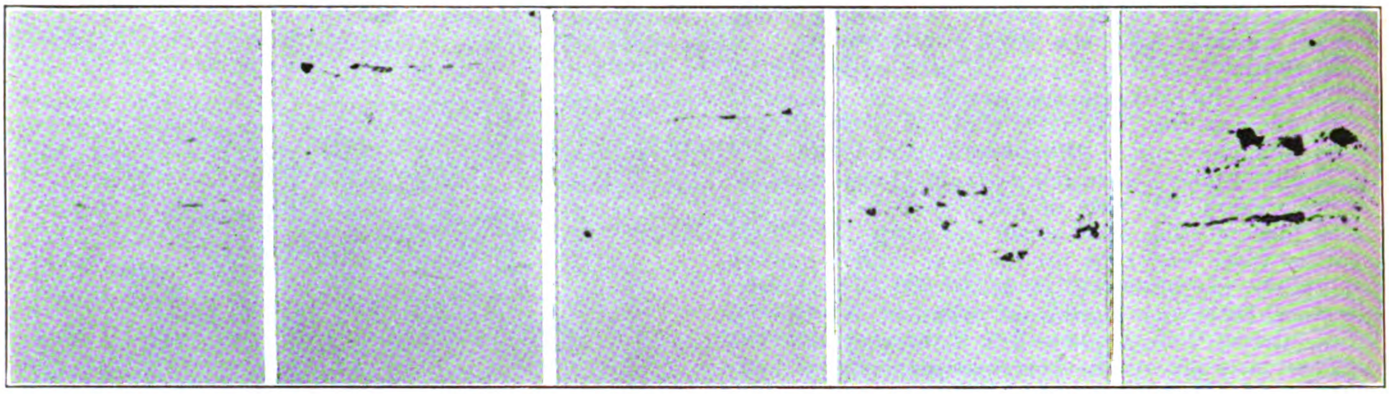


FIG. 2—Unetched sections of crankshaft steels illustrating the requirements of one steel manufacturer regarding freedom from inclusions. X100. a—Satisfactory but not highest rating. b and c—Passed but on the borderline between satisfactory and unsatisfactory steels. d and e—Unsatisfactory.

greater rigidity (stiffness) than the corresponding steel parts. Steels which might otherwise meet service requirements are therefore not as efficient as the aluminum and magnesium alloys for long columns and beams on account of their somewhat lower rigidity.

Quality—Aircraft steels are primarily quality steels, by which is meant that they must have a high order of purity, cleanliness and uniformity. High quality is of paramount importance since even occasional failures may cause serious losses of life and property. High quality tends to insure uniformity and, since low factors of safety are the rule in aircraft design, uniformity is necessary for reliability of performance. Inspection can make or mar the reputation of the products and plays an important role in the aircraft industry, since it is seldom possible to remedy the failure of important parts to function while in the air, as is the case with machines on land or water. Rigid inspection of vital parts of aircraft is not only desirable but quite generally practiced.

In individual cases each bar of steel, for such parts as piston pins, may be analyzed chemically and the treated parts each examined for flaws, hardness, etc. Crankshafts and connecting rods, are generally etched at some stage of manufacture to assist in the detection of minute imperfections and finally ground or polished all over. Removal of scratches by polishing tends to improve the resistance to repeated stress (fatigue) and helps in the detection of flaws in the final inspection.

One aircraft manufacturer has recently stated that, in the case of important metal parts, X-ray examination of each part would be well justified, if there was positive assurance of being able to detect the flaws which might produce failures. X-ray examination has already been used to advantage in the control of casting practice for important aluminum alloy castings, such as the cylinder heads of air-cooled engines, and will probably find broader application as the aircraft industry develops.

The subject of quality steels and what is a necessary degree of cleanliness and uniformity is one which is open to discussion. There is a small group, which believes that the steels now so widely used in the automotive industry are all that are necessary and that a dangerous situation is created, if what may be called super-quality materials are required to guarantee safe flying. A second and larger group feels that the standards of quality of aircraft materials cannot be too high and can point to numerous failures which have been eliminated, at least in part, by improved quality of the materials of construction.

The aircraft industry will probably go through several stages of development. At present, performance and reliability are being developed; at a later stage, the economic aspects will come to the fore and the cost per ton mile with equal or better performance and reliability will be scrutinized closely. This will undoubtedly create a demand for metals which are stronger per unit of weight and more uniform, in order that the dead loads may be decreased and the pay loads increased. Lack of reliability in the preliminary stages of development will affect the growth of the aircraft industry adversely; at later stages it will affect the economy of operation. Super-quality materials will be of immense benefit to the aircraft industry and are already in use.

The present situation with respect to quality in aircraft steels is probably analogous to that in the early days of the automotive industry. Specially selected stock, heat treated with special care, was used in vital parts of racing cars. When it was recognized that better mechanical properties could be obtained and that unusual laboratory tests would tend to insure reliability, then automotive manufacturers demanded such steels and applied those special tests to daily production.

As cleaner and more uniform steels are developed under the pressure of aircraft demands, they will unquestionably find application in other important fields. Difficulties will be encountered, but if the steel manufacturer will look upon the aircraft industry as a testing laboratory and utilize the lessons it will teach in obtaining cleanliness, uniformity and special properties, at least a part of the industry will learn much about steel making and about the application to quantity production of some of the information now available but not applied.

The aircraft industry is today calling on the steel industry to give it something a little better than the best. This challenge can and will undoubtedly be met by the steel industry and in the construction of flying equipment, as in any field of application, better, cleaner and more uniform steels are greatly to be desired.

(Continued on page 1445)

Steels Used by the Automotive Industry*

From the Steel Maker's Standpoint Automotive Steels Are Here Discussed in a Broad Way and with an Understanding of the Problems Involved in Their Utilization

By W. J. MacKENZIE†

A PAPER dealing with steel must of necessity be either of a strictly technical or a generally informative nature. A technical paper reports in detail the results obtained by research and study and generally relates to one particular phase of the industry. It states many facts and figures to substantiate these results. A non-technical paper attempts to tell a story of one or more phases of the industry without discussing the merits or demerits of any particular technical study or investigation. The nature of the title of this paper puts it at once into the informative or non-technical classification.

Steels used by the automotive industry are the carbon and the special, or alloy, steels. The carbon steels used are essentially of the same chemical composition as those developed for use in other fields and, with the advent of the automobile, were adopted, with some slight modifications, by that industry for use wherever service conditions permitted. The alloy steels were developed commercially by and with the automotive industry. They are distinctly the automobile steels, hence this paper will be chiefly confined to discussion of their production, properties, specifications, and applications or uses. The specifications and their applications are so dependent upon their production and the properties they will develop that this paper would not be complete without the mention in some detail of each. If a fine distinction is not always drawn in the following discussion and the subject matter seems to overlap, it is because one is dependent on the other.

Production of Alloy Steels

In telling of the production of the alloy steels for automotive use, it may be well to first mention briefly the two alloying elements, nickel and chromium, their early study, first applications, and, finally, their production commercially as the two chief alloying elements entering into our present automotive steels. This will be followed by the general classification of the automotive steels now in use and how they are produced.

Nearly a hundred years ago, Faraday and Stodart studied the properties of certain combinations of iron and nickel. The results obtained by these scientists led to further research and study, resulting finally in certain applications, the first of importance in this country being for armor plate by the United States Navy in the early nineties. This was followed by the use of nickel steel for bicycle tubes in 1897, and, finally, for the first automotive forgings, in 1903.

Alloys of chromium and iron were also studied by Faraday and Stodart, and we know that chromium steels were used nearly 60 years ago in certain members of the Eads bridge at St. Louis. But they, like the nickel steels, only came into real prominence with the automobile.

The automotive steels in general use today are the nickel steels (S.A.E. 2000 series), chromium-nickel (S.A.E. 3000 series), chromium-molybdenum (S.A.E. 4000 series), chromium (S.A.E. 5000 series), chromium-vanadium (S.A.E. 6000 series), silico-manganese (9200 series), and the manganese steels (G.M.C. 1300 series).

The bulk of these steels are made by the basic open-hearth process. The figures for 1927 show that approximately 81 per cent of the total tonnage of alloy steels of all types was made by this process. This 81 per cent is to a large extent used by the automotive industry, so that it will be fitting to limit this paper to steels made by that process.

The proper production of alloy steel varies from that of carbon steel in requiring a greater degree of refinement in the furnace and greater care in all subsequent operations. Briefly, the basic open-hearth alloy steel process consists of producing a super-refined carbon steel, during or at the completion of which refining period the alloying elements are added.

The alloy steel manufacturer today has very definite specifications for scrap, pig iron, and all raw materials entering into his product. The melting, heating and rolling operations are performed by men with years of alloy steel experience. These men have been trained to perform each operation carefully, because it has been learned over a period of time that inferior quality will result if a single step is neglected. I could cite innumerable instances to confirm this, but I believe one will suffice. Certain steels are of such chemical analysis that they are of an air hardening nature. The rolled billets and later the rolled bars must be cooled slowly, at a rate even slower than would occur on the hot bed. If they are not, internal ruptures will very likely occur, which will not entirely heal by subsequent working and treatment and will result in steels of lower physical properties.

The alloy steel manufacturer has also learned that, to produce alloy steels of quality, constancy of chemical analysis alone will not insure sufficient uniformity with successive heats of steel to meet the drastic requirements of the automotive industry.

Close chemical limits are not enough. To satisfy the industry, whose demand is for maximum freedom from segregation, the utmost in soundness, the minimum amount and size of non-metallic inclusions, controlled grain size, and all other modern requirements of quality steel, much has been learned, but a great deal still remains to be worked out. We are daily making progress. We sometimes find the cure for a problem before we get its real, scientific answer.

---

*Paper before the American Iron and Steel Institute, New York, October 26, 1928.

†Vice president, Interstate Iron and Steel Company, Chicago, Ill.

The metallurgist has come to play an important part in these studies.

The metallurgist works with each department that has a problem to solve. He is the quarterback who directs his plays to the department that is in trouble. Through his work with the open-hearth a great deal has been learned about the alloy additions, not only those that are added for the definite properties they impart but those others which are added for cleansing the metal of gases and non-metallic inclusions, for controlling grain size, etc. Today, he is working on the physical chemistry of slags, a study of the utmost importance and one that is just beginning to receive the attention that it deserves. He has studied mould design, melting, rolling, finishing and cooling temperatures, ingot soaking conditions; in fact, every operation entering into the making of the highest quality of steel. He is a vital factor in the field as well as at home. He is the contact man with the trade and brings home each problem as it arises. He has the full backing of the management at all times. And he gets full co-operation from every department because they realize the necessity of metallurgical advice to meet present-day problems.

Properties

So far, these comments have been limited to what I have chosen to call the true automotive steels and to that branch of the steel industry that produces the bulk of them. The skill and care required to make the steels of today have been discussed. Let us now consider the properties of the alloy steels from the standpoint of the automotive manufacturer, with a word as to what he first brought and what he brings today.

In the early days of the automobile little was known about the physical properties required. More than one purchasing agent was left to use his own judgment in buying steel. Many a blue print submitted by the engineering department for such parts as gears, knuckles, axles, etc., merely specified "steel," and it was up to the purchasing agent to get what he could and what he thought might work. We can all remember the number of times we were towed home as a result. These first cars showed the need of better steels; the alloy steels were tried and proved their possibilities. As time went on, better and better steels were developed and produced, so that today the purchasing agent when he buys alloy steels obtains steels of high physical properties and steels of uniformity.

High physical properties are necessary to resist the wear, fatigue and complex arrangement of dynamic stresses that obtain in the members of a light-weight, high-speed motor car. As an example, we produce daily a common S. A. E. alloy steel for gears which, with a single treatment, shows physical properties of 275,000 to 300,000 lbs. per sq. in. tensile strength and a reduction of area of 35 to 45 per cent at a minimum Brinell hardness of 500.

The automotive engineer today designs his parts with full confidence that the steel specified, when properly treated, will have the desired physical properties, or, said in another way, will do the work intended. This is the result of years of experience and co-operation with the steel maker. Our present-day chemical and physical specifications have been the outgrowth of this experience.

Steels of uniform properties are necessary to the manufacturer of parts that are to be free from distortion and of suitable physical strength after the mass-production methods of fabrication, treating and testing that are employed today. The automotive manufacturer can meet his schedules calling for thousands of cars per month because he gets uniform steels. He knows he can set his automatic machines to get hundreds of machined parts per tool; he knows that all he has to do is to set his heat-treating furnaces at certain prescribed temperatures and day in and day out he will get finished parts of uniform physical properties. He has made an immense saving in time and money. He has made it possible for nearly every one to own a car. I know of one large manufacturer who uses cold drawn nickel steel instead of plain carbon steel, which has all the strength required, because he can get a greater number of finished parts at a lower cost from the alloy steel, due to its uniformity.

Specifications

I have now come to the next general subject to be discussed, namely, the specifications for alloy steels.

The specifications given in Table A are the S. A. E. specifications in general use today. Only the chemical limits are shown. They have been assembled by the Society of Automotive Engineers and are the result of years of steel-using and steel-making experience. For each steel the S. A. E. has heat treatments for normalizing, quenching and tempering, and in the case of the nickel and chromium-nickel steels there are physical charts showing the physical properties to be expected in certain sections after suitable treatment. These will not be discussed. Their physical properties have already been mentioned in a general way. While there are, here and there, some variations in the chemical limits employed, most of the automobiles today are made of the steels in Table A. Those manufacturers who have analyses of their own can nearly always translate them into terms of some S. A. E. specification.

TABLE A—S. A. E. STEELS

Nickel Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phos. Max.	Sul. Max.	Silicon	Nickel Range
2015	.10–.20	.30–.60	.04	.045	.15– .30	.40– .60
2115	.10–.20	.30–.60	.04	.045	.15– .30	1.25–1.75
2315	.10–.20	.30–.60	.04	.045	....	3.25–3.75
2320	.15–.25	.50–.80	.04	.045	....	3.25–3.75
2330	.25–.35	.50–.80	.04	.045	....	3.25–3.75
2335	.30–.40	.50–.80	.04	.045	....	3.25–3.75
2340	.35–.45	.50–.80	.04	.045	....	3.25–3.75
2345	.40–.50	.50–.80	.04	.045	....	3.25–3.75
2350	.45–.55	.50–.80	.04	.045	....	3.25–3.75
2512	Mx..17	.30–.60	.04	.045	....	4.75–5.25

Nickel-Chromium Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phos. Max.	Sul. Max.	Silicon	Nickel Range
3115	.10–.20	.30–.60	.04	.045	1.00–1.50	.45– .75
3120	.15–.25	.30–.60	.04	.045	1.00–1.50	.45– .75
3125	.20–.30	.50–.80	.04	.045	1.00–1.50	.45– .75
3130	.25–.35	.50–.80	.04	.045	1.00–1.50	.45– .75
3135	.30–.40	.50–.80	.04	.045	1.00–1.50	.45– .75
3140	.35–.45	.50–.80	.04	.045	1.00–1.50	.45– .75
3215	.10–.20	.30–.60	.04	.040	1.50–2.00	.90–1.25
3220	.15–.25	.30–.60	.04	.040	1.50–2.00	.90–1.25
3230	.25–.35	.30–.60	.04	.040	1.50–2.00	.90–1.25

3240	.35–.45	.30–.60	.04	.040	1.50–2.00	.90–1.25
3245	.40–.50	.30–.60	.04	.040	1.50–2.00	.90–1.25
3250	.45–.55	.30–.60	.04	.040	1.50–2.00	.90–1.25
3312	Mx..17	.30–.60	.04	.040	3.25–3.75	1.25–1.75
3325	.20–.30	.30–.60	.04	.040	3.25–3.75	1.25–1.75
3335	.30–.40	.30–.60	.04	.040	3.25–3.75	1.25–1.75
3340	.35–.45	.30–.60	.04	.040	3.25–3.75	1.25–1.75
3415	.10–.20	.30–.60	.04	.040	2.75–3.25	.60– .95
3435	.30–.40	.30–.60	.04	.040	2.75–3.25	.60– .95
3450	.45–.55	.30–.60	.04	.040	2.75–3.25	.60– .95

Molybdenum Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phos. Max.	Sul. Max.	Chromium Range	Nickel Range	Molybdenum Range
4130 ...	.25–.35	.40–.70	.04	.045	.50– .80	....	.15–.25
4140 ...	.35–.45	.40–.70	.04	.045	.80–1.10	....	.15–.25
4150 ...	.45–.55	.40–.70	.04	.045	.80–1.10	....	.15–.25
4615 ...	.10–.20	.30–.60	.04	.045	....	1.50–2.00	.20–.30

Chromium Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phos. Max.	Sul. Max.	Chromium Range
5120	.15– .25	.30–.60	.04	.045	.60– .90
5140	.35– .45	.50–.80	.04	.045	.80–1.10
5150	.45– .55	.50–.80	.04	.045	.80–1.10
5210	.95–1.10	.20–.50	.03	.030	1.20–1.50

Chromium-Vanadium Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phos. Max.	Sul. Max.	Chromium Range	Vanadium	
						Min.	Des'd
6120	.15– .25	.50–.80	.04	.04	.80–1.10	.15	.18
6125	.20– .30	.50–.80	.04	.04	.80–1.10	.15	.18
6130	.25– .35	.50–.80	.04	.04	.80–1.10	.15	.18
6135	.30– .40	.50–.80	.04	.04	.80–1.10	.15	.18
6140	.35– .45	.50–.80	.04	.04	.80–1.10	.15	.18
6145	.40– .50	.50–.80	.04	.04	.80–1.10	.15	.18
6250	.45– .55	.50–.80	.04	.04	.80–1.10	.15	.18
6195	.90–1.05	.20–.45	.03	.03	.80–1.10	.15	.18

Silico-Manganese Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phas. Max.	Sul. Max.	Silicon Range
9250	.45–.55	.60–.90	.045	.045	1.80–2.20
9260	.55–.65	.60–.90	.045	.045	1.80–2.20

Carbon Steels

S.A.E. Steel No.	Carbon Range	Manganese Range	Phos. Max.	Sul. Max.
1010	.05– .15	.30– .60	.045	.05
1015	.10– .20	.30– .60	.045	.05
1020	.15– .25	.30– .60	.045	.05
1025	.20– .30	.50– .80	.045	.05
1030	.25– .35	.50– .80	.045	.05
1035	.30– .40	.50– .80	.045	.05
1040	.35– .45	.50– .80	.045	.05
1045	.40– .50	.50– .80	.045	.05
1046	Discontinued July, 1927			
1050	.45– .55	.50– .80	.045	.05
1095	.90–1.05	.25– .50	.040	.05
1350*	.45– .55	.90–1.20	.040	.05
1360*	.55– .70	.90–1.20	.040	.05

*Silicon content for 1350 and 1360 shall not exceed 0.30 per cent.

Besides the chemical limitations, there are certain other requirements that are being specified by some manufacturers for which there are no standards. I have already mentioned soundness, minimum amount and size of non-metallics, grain size, etc. The lack of standards frequently puts a burden on the steel mills. A specification regarding the degree of freedom from non-metallic inclusions may be cited as an example. Alloy steel manufacturers recognize the possible harmful effects of dirty steel and, therefore, consistently produce steels of exceptional cleanliness. Nevertheless, it must be considered that slag in some form or other, even in minute quantities as it exists today, is a normal constituent of all steel produced commercially. The steel producer is exposed to an unjust and uneconomical hardship by a user specifying cleanliness, because any classification of steel on the basis of slag or non-metallic inclusions at present is a matter of individual opinion, and opinions may vary widely. There is a real need for some definite quantitative and standardized classification of this condition if it is to be part of some manufacturer's specification.

The same comments apply to specifications regarding the appearance of fractured surfaces, appearances of surfaces exposed to acid attack, and the like, all of which involve innumerable variables and finally resolve themselves into matters of opinion. I have a profound respect for enlightened opinion, but feel that both steel producers and steel consumers would benefit by confining specifications to tests capable of quantitative measurements and which approximate service conditions. This unsatisfactory condition is due partly perhaps to the fact that the only well developed and standardized test at present is a static tensile test, whereas the stresses to which the steel is subjected are dynamic. The development of a commercially practical and efficient test for the dynamic properties of steel is urgently needed.

Applications

I have now come to the last subject to be discussed and that is to tell briefly the uses of the alloy steels most commonly employed by the automotive industry. It will serve to illustrate the properties of each alloy type, except the silico-manganese type, by considering these classes of steel as each having a carbon content of approximately .15, .30 and 50 per cent. Those steels having .15 per cent cabon are case carburizing or surface hardening; those having .30 per cent carbon are water hardening except in small sizes or irregular sections; while those having .50 per cent carbon are oil hardening in all sizes. The alloy steels to be discussed are practically all used in the heat-treated condition, since it is heat treatment that brings out their full potentialities and makes them vastly superior to carbon steels. A few words will be said about each classification and its uses.

Nickel Steel

The addition of nickel to carbon steel increases the ultimate strength and hardness without decreasing the ductility. It lowers the hardening temperature of the steel and permits of obtaining great hardness through oil quenching. From a fabrication standpoint, this means simplified heat-treating operations and parts possessing greater freedom from scale, distortion and danger of cracking. The properties conferred upon steel by nickel can be manipulated to produce parts of great hardness and wear-resisting ability with reasonable toughness, such as is required in a clash gear; or these properties can be adjusted to a balance of strength and ductility that the part will withstand such severe shock and torsional stresses as are set up in axles or driving shafts. Nickel inhibits the graingrowing tendency of steel undergoing thermal treatment. For this reason, nickel steels are widely used for carburized parts.

The most important nickel carburizing steel is S. A. E. 2315. It is widely used throughout the automobile industry for parts wherein strength, case hardness, and freedom from distortion are all important. Its freedom from grain growth at carburizing temperatures makes it possible in many cases to omit the high temperature or core refining treatment subsequent to carburizing, thus effecting an operating economy and decreasing scaling, decarbonization and distortion, which is a great advantage with such parts as ring gears. This steel is widely used in different gears and pinions, and similar parts. A nickel carburizing steel used where the greatest core strength is demanded is S. A. E. 2512. After carburizing, parts made of this steel can be hardened at a temperature as low as 1325 deg. F., which permits exceptional freedom from scaling and distortion. S. A. E. 2512 steel is used where great strength and toughness along with wearing properties are required, as in pinion gears, steering worms and similar parts for motor trucks. A semi-alloy steel containing approximately ½ per cent nickel is used for relatively unimportant and replacement carburized parts. Its advantage over carbon steel consists chiefly of a slightly tougher core and generally satisfactory hardness after oil quenching. This steel is designated as S. A. E. 2015.

S. A. E. 2330 is a nickel forging steel. It is used where great strength and toughness are desirable, as in steering knuckles, connecting rods, highly stressed bolts, etc. It forges, machines and heat-treats easily, being water quenched excepting in small and irregular sections. Water quenching, subject to variable tempering temperatures, produces a tensile strength range of 125,000 to 225,000 lbs. per sq. in. Parts made of this steel are generally heat treated before finished machining, which operation can be done on a production scale so long as the hardness does not exceed about 300 Brinell.

S. A. E. 2350 is a popular nickel steel which is used where severe service is encountered. With proper manufacture and fabrication treatment, its potentialities represent probably the maximum combination of properties obtainable with a simple alloy steel. These properties are great strength, exceptional toughness, reasonable machinability, satisfactory depth of hardening, and great wear resistance. In the automotive industry this steel is used chiefly for oil-hardened transmission gears, and various highly stressed parts in truck and tractor construction.

The addition of chromium to steel greatly increases the hardness and wearing quality. By proper adjustment of composition and thermal treatment, chrome steel can be made to yield excellent service against the complex stresses that prevail in a steering knuckle or to withstand the severe abrasion that is applied to hardened transmission gears. By reason of its tendency to promote a fine grain and to increase the depth of hardening, chromium in steel facilitates the heat treatment of large sections and decreases the necessity for drastic treatment of small sections.

The chromium steel in general use with the lowest amount of carbon is S. A. E. 5120. A considerable amount of this steel is used in case-carburized parts, for which purpose the carbon is usually specified below .22 per cent. This steel machines, carburizes and hardens readily, producing a very hard case. It is used for piston pins, bolts, and some case-carburized gears.

No. 5130, while not an official S. A. E. number, in following the S. A. E. system of classification designates a widely used chromium steel of the following analysis: carbon, .25 to .35 per cent, manganese .50 to .80 per cent; chromium, .80 to 1.10 per cent. This type of steel, usually with a restricted carbon range, is used for crank shafts, connecting rods, axles, and similar parts. It has a wide range of physical properties after a simple water-quenching heat treatment. Like the other water-hardened alloy steels, it is frequently heat treated before machining, which permits of the production of bright and clean surfaces on the finished part and generally eliminates straightening troubles.

S. A. E. 5150 is an oil-hardening chromium steel. It is used where high strength and great wear resistance are demanded. It finds extensive application in automobile transmission gears. The manufacture of the modern quiet-running automobile transmission presents many problems in highly controlled production annealing, specialized machinability and distortion-free hardening operations. To all these, properly made 5150 steel, with the restricted carbon range usually employed in the automobile industry, is readily amenable. A modified 5150 steel without an official S. A. E. number is rather widely used for springs. The analysis of this steel usually comes within the following range: carbon, .47 to .52 per cent; manganese, .70 to .95 per cent; chromium, 1.00 to 1.20 per cent. Spring-forming and heat-treating operations in the automobile industry are usually done in continuous furnaces on a large scale production basis, so that the need for uniformity of successive heats of steel is imperative. Chrome spring steel fills this need admirably. After oil quenching at about 1550 deg. F. and drawing at 900 deg. F., it possesses sufficient strength to be resilent and has sufficient toughness to absorb road shocks, which is the combination necessary for an automobile spring.

Nickel-Chromium Steel

It has been learned in developing steels for severe service that the addition of more than one alloying element is frequently of great advantage. The effect of some combinations of alloys is found to be much better than could be obtained with equivalent amounts of any one of the alloys alone. The combination of nickel and chromium in alloy steel illustrates this principle. The metallurgical influence of nickel is exerted on the iron or ferrite in steel, while the influence of chromium is confined chiefly to the carbon or carbide. This combination produces an alloy steel with a higher elastic ratio, greater hardness, and higher impact and fatigue resistance than is possessed by the simple alloy steels. It is a frequent statement throughout the automotive industry that properly treated nickel-chromium steels possess the maximum combination of desirable properties of any of the common S. A. E. steels.

S. A. E. 3115 is the nickel-chromium carburizing steel. This steel carburizes efficiently, producing a part with a strong core and a hard case. The strength of the case of a carburized part is largely dependent upon the strength of the core which supports it. For this reason, S. A. E. 3115 is advantageously applied in parts, such as some highly stressed beveled gears, where the case is subjected in service to a severe crushing action. Since it is cheaper than 2315 steel it is sometimes used in ring gears against 2315 pinions.

S. A. E. 3130 is the nickel-chromium forging steel. The strength, impact and fatigue resistance of this steel make it highly desirable for such parts as steering knuckles, drive shafts, severely stressed bolts, etc. It machines readily after heat treatment at any reasonable hardness. It may be water quenched excepting in small sections. Its deep hardening property permits of the uniform hardening of large sections. S. A. E. 3130 may justly be designated an all-purpose alloy forging steel.

S. A. E. 3150 is not an official S. A. E. number but is used to designate a nickel-chromium steel analyzing: carbon, .45 to .55 per cent; manganese, .50 to .80 per cent; nickel, 1.00 to 1.50 per cent; chromium, .45 to .75 per cent. Steel with the carbon on the low side of this range is used for some crankshafts, pump shafts and parts requiring similar properties. It is admirably suited for heat-treated forgings of large section. It is used in the automotive industry for severely stressed oil hardened gears. S. A. E. 3150 responds readily to the usual automobile fabrication processes consisting of forging, machining and heat treating.

S. A. E. 3240, S. A. E. 3245 and S. A. E. 3250 are used for parts subjected to severe conditions where great dynamic strength is needed. S. A. E. 3240 is used for shafts, while 3245 and 3250 are more generally used for gears. These steels are particularly adaptable to large sections because of the increased chromium content which permits of hardening to a greater depth, and subsequent grain refining by tempering.

Chromium-Vanadium Steel

The addition of vanadium to steel increases the tensile strength, the impact resistance and the fineness of grain. It is a denitrogenizer as well as a deoxidizer. It is used generally as an intensifying or secondary alloying element chiefly with chromium. The chromium-vanadium steels find a wide application because of their toughness and resistance to reversals of stress or fatigue. A very advantageous influence of vanadium in chromium-vanadium steel is the widening of the hardening temperature range which means that the steel is rendered less susceptible to the bad effect of fluctuations in the heat-treating practice. It is, therefore, a more "fool proof" alloy steel.

The low-carbon vanadium steel in general use is S. A. E. 6120. For carburized automotive parts, the carbon range of this steel is usually desired at .13 to .18 per cent. This steel is used for piston pins and various types of gears and pinions. Carburizing this steel produces a hard case having very great wear resistance. A modification of this steel has recently come into use in the automobile industry for ring gears and pinions. It has no numerical designation but is known as nickel-chromium-vanadium steel. The analysis specification is the same as for S. A. E. 6120 except for the addition of .50 to .75 per cent nickel. The advantages of this steel consist of slightly increased strength and the fact that the high temperature or core refining treatment may safely be omitted in many instances, which helps to reduce distortion.

S. A. E. 6130 is the chromium-vanadium steel used for miscellaneous forgings. It is a very tough grade of alloy forging steel and finds wide application throughout the automotive industry for parts subject to shock. A rather wide range of forging temperature is permissible which is an advantage in a high production process. A 6130 steel can be quenched in water or water solutions except in small sections. It is fairly easily machined at a tensile strength as high as 150,000 lbs. per sq. in. It is used for steering arms, connecting rods, propeller shafts, etc.

S. A. E. 6150 is a high strength steel of good shock resistance. In the automotive industry, it is used chiefly for oil-hardened transmission gears. The problems attendant upon the production of quiet-running automobile transmissions, which are so necessary to the saleability of the modern closed car, have already been referred to. S. A. E. 6150 steel, properly handled, contributes to the solution of these problems. Gear manufacturers frequently find it necessary to resort to cyanide immersion in the hardening of transmission gears to reduce the tendency toward pitting of the gear teeth in service. The vanadium in chromium-vanadium steel helps to suppress whatever harmful tendency the nitrogen from cyanide may have. S. A. E. 6150 steel, usually with slight increase in the manganese and chromium contents over the S. A. E. standard, is widely used for springs throughout the automobile industry. It is probably the concensus of opinion that this steel represents the best material now available for leaf springs. The properties imparted to steel by the combination of chromium and vanadium render it well suited to resist the shocks, repetitions and reversals of stress that occur in spring service. The comparatively wide range over which chromium-vanadium steel may be heated without damage is of great advantage in spring manufacturing plants lacking close technical regulation of the forming and heat-treating processes.

Chromium-Molybdenum and Nickel-Molybdenum Steels

The addition of molybdenum to common steel results in an increase in the hardening power of the steel and in its machinability at a given hardness. Similarly to vanadium, the full effect of molybdenum is not realized except in conjunction with one or more of the other major alloying elements, such as chromium or nickel. The bulk of the steel containing molybdenum used to date by the automotive industry is in the form of chromium-molybdenum steel. The application of this comparatively new steel in the automotive industry is confined chiefly to the types S. A. E. 4130 and 4140. The advantages of chromium-molybdenum steel consist of a higher drawing temperature for the attainment of given physical properties, comparatively easy machinability at high hardness limits, great depth hardening properties and a good combination of strength and ductility. Chromium-molybdenum steel has not been considered successful for use in carburized parts. This is due primarily to the fact that the deep hardening properties of the steel result in too great hardening and hence embrittlement of the core. The carburizing steel of this series is a nickel-molybdenum alloy steel designated S. A. E. 4615.

S. A. E. 4615 steel has the ability to produce great hardness of the case on a carburized part with an oil quench. This, plus the fact that good core ductility may be had without the high temperature treatment, permits of the production of carburized parts with minimum distortion. Where the section permits of drastic quenching, a scleroscope hardness of about 100 may be produced by water hardening a carburized

(Continued on page 1460)

Meeting Boosts Metallurgical Research

Engineers and Metallurgists from Many Steel Companies Gather to Hear Reports on Various Phases of Steel Manufacture and Treatment

THAT the value of metallurgical research is correctly appraised was made evident at the meeting of steel plant engineers and metallurgists held in Pittsburgh on October 19. At this meeting, sponsored by an advisory board to the Carnegie Institute of Technology and the U. S. Bureau of Mines, enthusiastic approval was accorded the papers and reports of progress presented. These papers and reports represented the accomplishments of investigators who are working in co-operation with, and receive support from, the Bureau of Mines, the Advisory Board, the Carnegie Institute of Technology.

As will be noticed on the program, the progress reports were discussed by men who, in their labors, have been closely identified with the subjects covered by the reports. There was a unanimity of opinion that the investigations at the institute and the bureau should receive the hearty encouragement of all those companies that may be benefited. There were also expressions from many speakers to the effect that the work being performed by Dr. C. H. Herty, Jr., Dr. V. N. Krivobok, and their associates is of direct practical application to the solution of problems arising in the manufacture and treatment of steel. Frequently the results of an intense research into some phase of steel manufacture possess very little of practical value, but research such as that conducted by Dr. Herty on the reactions in the open-hearth furnace, can be comprehended, so the speakers asserted, by the men who supervise the operation of the furnaces and hence can be incorporated into practice.

PROGRAM

Morning Technical Session

Auditorium, U. S. Bureau of Mines, 4800 Forbes Street
Mr. T. D. Lynch, presiding

9:45–10:00—Address of Welcome
Mr. T. D. Lynch, chairman, Metallurgical Advisory Board.

Case Carburizing Research

10:00–10:15—Illustrated Report
Dr. V. N. Krivobok, assistant, Bureau of Metallurgical Research, Carnegie Institute of Technology.

10:15–10:45—Discussion
Dr. C. H. Herty, Jr., physical chemist, U. S. Bureau of Mines.
Dr. H. W. Gillett, chief, Division of Metallurgy, U. S. Bureau of Standards.
Mr. M. A. Grossmann, metallurgist, Central Alloy Steel Corporation.

Bureau of Metallurgical Research

10:45–11:00—Progress Report
Dr. F. M. Walters, Jr., director, Bureau of Metallurgical Research, Carnegie Institute of Technology.

11:00–11:15—The Application of X-rays to the Study of Metals
Dr. J. B. Friauf, associate, Bureau of Metallurgical Research, Carnegie Institute of Technology.

11:15–11:35—Illustrated Report on Metallurgical Work
Dr. V. N. Krivobok.

11:35:11:55—Report on Iron-Manganese Alloys
Dr. V. N. Krivobok.

11:55–12:30—Discussion
Dr. H. W. Gillett, chief, Division of Metallurgy, U. S. Bureau of Standards.
Dr. Zay Jeffries, consultant metallurgist, Aluminum Company of America, General Electric Company, National Tube Company.
Prof. Bradley Stoughton, Department of Metallurgy, Lehigh University.
Mr. A. V. DeForest, research engineer, American Chain Company.

Afternoon Technical Session

Auditorium, U. S. Bureau of Mines

The Physical Chemistry of Steel Making

Mr. T. D. Lynch, presiding

1:45– 2:00—Introductory Remarks
Mr. A. C. Fieldner, chief engineer, Experiment Stations Division, U. S. Bureau of Mines, Washington, D. C.

2:00– 2:45—Illustrated Progress Report on Fundamental Studies in the Laboratory
Dr. C. H. Herty, Jr., physical chemist, U. S. Bureau of Mines.

2:45– 3:15—Discussion
Dr. John Johnson, director, Department of Research and Technology, United States Steel Corporation.
Mr. A. L. Field, metallurgical engineer, Union Carbide and Carbon Research Laboratories
James Aston, Department Mining and Metallurgy, Carnegie Institute of Technology.
Dr. D. F. McFarland, Department of Metallurgy, Pennsylvania State College.

3:15– 4:00—Illustrated Progress Report on Plant Research in the Open-Hearth
Dr. C. H. Herty, Jr.

4:00– 4:30—Discussion
Mr. C. L. Kinney, director, Physical Laboratory, Illinois Steel Company
Mr. L. F. Reinartz, assistant general superintendent, American Rolling Mill Company
Mr. W. J. Ballantyne, superintendent of open-hearths, Jones & Laughlin Steel Corporation.

7:00—Informal Dinner, followed by Evening Session. Annex Ball Room, Pittsburgh Athletic Association
Dr. Thomas S. Baker, president, Carnegie Institute of Technology, presiding

Address—Dr. W. H. Hatfield, director of research, Brown-Firth Research Laboratories, England

Looking Ahead—Scott Turner, director, U. S. Bureau of Mines

Dr. Herty said in part with reference to deoxidation with silicon in the open-hearth furnace:

"One of the primary factors in the rate of elimination of silicates from open-hearth steel is the size of the particle formed on deoxidation. If excess silicon is added to a medium or high-carbon steel very small glassy particles are formed which rise slowly out of the steel. On the other hand, if there is sufficient iron oxide or manganese oxide to flux the silicon, a rapid increase in rate of elimination is found due to the increased size of the silicate particle.

"From the results of the work on deoxidation with silicon it is possible to predict just what type of inclusion will be formed with any silicon addition to any type of open-hearth steel, provided manganese is not added at the same time. A number of open-hearth heats have been critically studied and the results have shown that if a large particle is formed on deoxidation it will be eliminated from the steel approximately 10 times as fast as the small type of particle formed when the steel is dead-killed with excess silicon. These results make it possible to designate the optimum amount of silicon to add to any open-hearth heat in killing in the furnace and show that if clean steel is desired certain grades of steel should be killed in the furnace with silicon and manganese rather than silicon alone."

A most encouraging feature of the meeting was the large attendance at all sessions; especially that in the afternoon, at which over 200 were registered.

At the dinner which was held at the Pittsburgh Athletic Club, Dr. Thomas S. Baker, presided. Before introducing the speakers, he related some historical facts concerning the formation of the organization, whose object is the promotion of metallurgical research. The first speaker, Dr. W. H. Hatfield, discussed research in a general way. He advised caution in the pursuit of research stating, that, "the race is not always to the swift." Dr. Hatfield complimented Dr. Herty upon the excellence of his investigations. Mr. Scott Turner, director of the Bureau of Mines, in reviewing the work of his department, called attention to the extensive work that was being carried on under the direction of the Bureau of Mines. He stated that of the total amount—$44,000—contributed to meet the expenses of metallurgical research the Bureau of Mines had appropriated $27,000, and the Carnegie Institute and 29 steel companies the remaining portion.

F. N. Speller, of the National Tube Company succeeds T. D. Lynch as chairman of the Advisory Board; G. A. Reinhart, of the Youngstown Sheet & Tube Company will serve as vice-chairman.

Recent Observations on Some European Iron and Steel Conditions

(Continued from page 1435)

gether with their efficiency, is the cause of this change to turbines, both high and low pressure.

The present trend is to equip plants with modern, efficient steam boilers, turbines, etc., and gradually work into high-pressure superheated steam equipment to accomplish a saving. One company has just completed a 375 to 400 lbs., 700 deg. superheated steam installation and turbo-blowers with this end in view. Some of our new steam plants are using 350 lbs. working pressure.

German Blast Furnaces

Raw Materials—The following are some of the materials in use at Hamborn Works, August Thyssen Hutte, A. G.:

Swedish lump ore containing 62 per cent Fe.

African and Spanish ores containing 30 to 40 per cent Fe.

French minettes containing 32 to 40 per cent Fe.

Sinter made from flue dust and pyrites containing 40 to 50 per cent Fe.

Sinter made from Swedish concentrates containing 66 per cent Fe.

Flue dust briquettes.

Limestone, large lumps noted, not screened.

Coke, all by-product, small and regular.

When making their best month's run at the Hamborn plant the following ores were used:

		Per cent
Swedish magnetites	Kiiruna D	25.1
	Grangesberg	23.2
	Kaptens	0.2
Djerissa (African red ore)		18.6
Normandy ores		12.0
Siegerland roasted spathic		0.4
Manganiferous brown ores		3.7
Open-hearth slag		4.8
Sintered flue dust		8.7
Flue dust briquettes		0.1
Scrap		0.7
M. Zaita—Phosphate		2.5
		100.0
Limestone		5.5

What is hereafter called good ore mixture at this German plant was 49 per cent Swedish ores and 51 per cent lean ores.

(To be continued)

Steel Requirements of Aircraft Industry

(Continued from page 1438)

An example may be given to illustrate the present trend. For some time, one steel manufacturer has examined microscopically for inclusions all alloy steel billets intended for high strength aircraft engine parts such as crankshafts. Trapped inclusions to the extent shown in Figs. 2d and 2e have caused rejection in the mill. Steel of the character shown in Figs. 2b and 2c is considered to be about the limit of acceptability, while that represented in Fig. 2a is considered good but is not given the highest rating.

The commercial production of super-clean steels requires modifications in mill practice and the trend has been toward the electric furnace product, since it is difficult to meet these requirements regularly with open-hearth steels. In the cases shown in Fig. 2, cleanliness has been obtained at the expense of other desirable properties. The super-clean steels are generally coarse grained and introduce problems in heat treatment through difficulties in securing complete solution of the ferrite without increasing the tendency to crack in hardening. Impact values of the quenched and tempered steels also may be low and the forging ranges are narraw in comparison with the corresponding open-hearth products.

With such difficulties, the need for super-clean steels may be questioned. Parts such as crankshafts have been made in the past from relatively dirty steels and many are known to have given satisfactory performance. This is not a valid argument for dirty steel, since the inclusions may not have been at "strategic" points where they might cause trouble. The difficulty lies in the fact that it is impracticable to keep the inclusions at points where they will do no harm. Where reliability is paramount super-cleanliness and uniformity are the only reasonable safeguards.

(To be continued)

Digitized by Google Original from UNIVERSITY OF MICHIGAN

Relative Cost and Value of Fuels

Data Here Given Comparing the Relative Value of Various Fuels Against Their Cost Brings Out Clearly the Advantages of Producer Gas in Open-Hearth and Heating Furnace Operation

By E. A. W. JEFFERIES*

THIS question resolves itself first into an examination of the cost per 1,000,000 Btu. in each of the four main fuels available, namely: Producer gas, fuel oil, coke-oven gas, and natural gas. Other considerations may affect the relative desirability of one fuel over another for certain purposes, but it is very difficult to weigh the value of these qualities in money for the reason that data are scarce and opinions vary widely. For example, in the open-hearth furnace so much depends on the construction of ports and roof and their suitability for using a given fuel to the best advantage. Some experience places a greater value on oil than is indicated by the relative Btu. Other experience indicates no saving in time and only a comparatively small difference in furnace maintenance, with no exact comparative data available.

In heating furnaces, on the other hand, the cutting action and spot heating of oil is detrimental and better results are obtained by the mild uniform heat of producer gas. This also is difficult to appraise in money, although a very important factor.

The cleanest and most desirable all round fuel for every purpose is natural gas. The large quantity of air required to burn it makes its destructive possibilities less than oil, but its cost in most localities is prohibitive.

The relative cost per 1,000,000 Btu. available will practically always be the determining factor in selecting fuel, as it should be, wherever large quantities of heat are required.

Cost of Producer Gas Per 1,000,000 Btu.

This depends primarily on the cost of gas-making coal at the point where it is required, which ordinarily varies in the industrial centers of the U. S. A. between $2.50 and $5.00 per net ton.

Added to this is the cost of the investment in gas plant, and of amortization, maintenance, labor, steam and power.

The cost of a battery of four 1927 Morgan producer-gas machines including short gas flues, foundations, building, coal elevator, crusher and all equipment erected is about $120,000 which at 15 per cent per annum for interest, depreciation and amortization gives a fixed charge of $18,000 per annum. (Five per cent interest and 10 years life of plant.)

(This estimate of cost of gas houses, etc., is based on the most expensive construction with tunnel for coal conveyor. A first class gas house with four producers and overhead crane for handling coal and ash including all equipment can be erected for less than $96,000—which reduces the cost of gasification 4 cts. per ton).

This battery working at full capacity will gasify 12 tons of coal per hour continuously.

The cost of pumping water for cooling purposes at the rate of 300 gals. per hour per producer is too small and indefinite to consider as a separate item. It is more than covered by excess allowances for labor, steam and power.

Working 48 weeks, 6½ days per week, 7,500 hours per year gives a total of 90,000 tons per year at which rate the cost of fixed or capital charges would be	20 cts.	Per ton of coal gasified.
The labor required for operation including handling of coal, soot and ash will not exceed $35 per day, which allows for 7 men per 24 hrs. each working 8 hrs.	12 cts.	
Maintenance can be safely figured at	2 cts.	
Cost of steam (500 lbs. at 80 cts. per ton)	20 cts.	
Cost of power (1½ hp. per producer) at 2 cts. per hp.hr.	1 ct.	
	55 cts.	

In case the plant is run at one-half its full capacity, namely at 3,000 lbs. per hour per producer, then the total cost of fixed charges, labor, maintenance and power would remain substantially unchanged, but the quantity of steam would be reduced 50 per cent. The cost of gasification would then be 90 cts. per ton of coal gasified. At three-quarter capacity 67 cts.

The gas from a ton (2000 lbs.) of fairly good gas coal yields 24,000,000 Btu. (see Addendum), therefore we have the following costs per 1,000,000 Btu. in the form of producer gas delivered to the furnace:

Cost of coal per ton, dollars	2.50	3.75	5.00
Working at 6000 lbs. per hr., cents	12.7	18.0	23.1
Working at 4500 lbs. per hr., cents	13.2	18.4	23.6
Working at 3000 lbs. per hr., cents	14.1	19.4	24.6

Cost of Oil Per 1,000,000 Btu.

At the present time, in the chief industrial centers of the U. S. A. the cost of oil, plus cost of pumping it, plus cost of compressed air to atomize it, and all sundry expense connected with storage, heating and piping averages 8 cts. per gal. in the furnace. This may vary between 7½ and 8½ cts.

The Btu. per gallon averages 140,000, therefore it requires 7.14 gals. to furnish a 1,000,000 Btu. costing 57 cts. in the furnace, which corresponds to paying $13.00 per ton for gas coal in cars at a modern Morgan producer-gas plant.

Cost of Coke-Oven Gas per 1,000,000 Btu.

Coke-oven gas is made by steel companies as a by-product in the manufacture of coke. It is also made by gas companies as the principal product and coke is then the by-product. In either case the cost of the gas is indeterminate unless the value of the coke at the plant is known or fixed arbitrarily.

Ordinarily the only measure of the cost of using coke-oven gas is the price at which it is purchased by the gas companies except where no such market is available. In the latter case it must be used in the furnaces or wasted, in which case its cost is not a factor in this study.

---

*Morgan Construction Company, Worcester, Mass.

In most cases it can be sold advantageously and the practice of selling it instead of using it in the furnaces is rapidly developing. The price obtained early in this practice was 40 cts. per 1000 cu. ft. in Boston, but this has been gradually reduced, being now 30 cts. in Philadelphia, 26 cts. in Buffalo and 22 cts. in Chicago.

The heating value of coke-oven gas varies between 525 and 575 Btu. per cu. ft. Taking an average of 550 it requires 1818 cu. ft. to supply 1,000,000 Btu. costing 40 cts. when the gas sells for 22 cts. per 1000 or 47.27 cts. when the gas sells for 26 cts. per 1000. In order to compete with producer gas its value at the furnace can only be figured at 7.3 cts. per 1000 cu. ft. when gas coal is $2.50 per ton or 13.0 cts. when coal costs $5.00 per ton.

Any price obtained by selling the coke-oven gas above these latter figures (which should be determined accurately for each location) is clear gain over using it in the furnaces.

Cost of Natural Gas Per 1,000,000 Btu.

The heating value of natural gas varies between 950 and 1050 Btu. per cu. ft. and is generally credited with an average of 1000. On this basis 1000 cu. ft. yields 1,000,000 Btu. It can therefore only be used on equality with producer gas where it is available at a cost of 13.2 to 23.6 cts. per 1000 cu. ft. depending on the price of gas-making coal in that locality. But it is not now available in the large steel making centers for less than twice its value, as compared with the cost of producer gas at those centers. Consequently it is not much used except for domestic and small industrial purposes.

It will be noted by the above table that when gas coal costs only $2.50 per ton it would not pay to use oil even if free unless the cost of distribution, heating and atomizing could be reduced to 13.2 ÷ 7.14 = 1.85 cts. per gal. Also that when coal costs $5.00 per ton oil is only worth 0.8 cts. per gal. on an equal basis of overall cost for heat.

Summary of Relative Values (Averages) Compared with Producer-Gas.

Gas coal	Value of fuel oil per gallon, after allowing 2½ cts. for distribution and atomizing, cents	Value of coke oven gas per 1000 cu.ft., cents	Value of natural gas per 1000 cu.ft. or million Btu., cents
$2.50 per ton	13.2 ÷ 7.14 — 2.5 = —.65*	7.3	13.2
$3.75 per ton	18.4 ÷ 7.14 — 2.5 = .08	10.0	18.4
$5.00 per ton	23.6 ÷ 7.14 — 2.5 = .80	13.0	23.6

*This means that oil is worth .65 cts. per gal. less than nothing (with coal at $2.50 per ton) on account of the cost of preparing it for use which is at least 2½ cts. per gal. and is equivalent to paying $3.50 per ton for coal and gasifying it, even if the oil itself costs nothing.

Fuel Cost in Making Steel

Below is a comparative study of the fuel costs of making steel with producer gas, fuel oil and coke-oven gas.

This is not a complete study of the cost of making steel, but only of relative fuel costs for heat put into the furnace. Other factors affect the overall cost of making steel but this study shows the great intital advantage in cost possessed by producer gas. Oil, for example, has a handicap of over $2.00 per gross ton of steel which must be overcome by other advantages before it can compete with gas made in a modern Morgan producer-gas machine.

The attached chart shows at a glance the relative cost of producer gas, fuel oil and coke-oven gas for melting 1 ton of steel in an open-hearth furnace.

Herewith is an extension of this study of relative fuel cost to cover heating furnaces also.

Summing up these computations it is evident that, no matter for what purpose producer gas is used, it has the advantage of costing less than 33 per cent of the cost of oil, and less than 40 per cent of the cost of coke-oven gas for a given amount of heat supplied by a suitably proportional plant of modern producer-gas machines.

Average Fuel Cost of Making Steel in Open-Hearth Furnaces—Dollars Per Ton.

Producer gas made in modern Morgan machines including all costs of gasification—						
Coal per gross ton of steel, pounds	350	400	450	500	550	800
1,000,000 Btu. in furnace	4.200	4.800	5.400	6.000	6.600	7.200
Cost with coal at $2.50 per net ton	$0.554	$0.634	$0.713	$0.79	$0.87	$0.95
Cost with coal at 3.75 per net ton	0.778	0.883	0.994	1.10	1.21	1.33
Cost with coal at 5.00 per net ton	0.993	1.133	1.275	1.42	1.56	1.70
Gas from 1 lb. coal = 12,000 Btu. in furnace. (See Addendum)						
Cost of equivalent Btu. in fuel oil—						
At 8 cts. per gal. delivered to furnace including cost of compressed air, piping, etc., (equal to $13.00 per ton for coal).						
One gallon oil = 140,000 Btu.						
Gallons oil	30.0	34.3	38.6	43.0	47.1	5.14
Dollars	2.40	2.74	3.09	3.44	3.77	4.11
Cost of equivalent Btu. in coke gas—						
At 26 cts. per 1000 cu. ft., 550 Btu. per cu. ft.						
Gas from 1 lb. coal = 21.8 cu. ft. coke gas (equal to $11.34 per ton for coal).						
Cu. ft.	7630	8720	9810	10900	11990	13080
Dollars	1.98	2.27	2.55	2.83	3.12	3.40

The best known continuous record of fuel used for melting steel in open-hearth furnaces comes from the Weirton Steel Company whose 250-ton furnaces (melting 300 tons per heat) operating on producer gas, use an average of only 330 lbs. of coal per gross ton of steel melted.

From this study it appears that after making full allowance for all expenses of gasification and paying $3.75 per ton for coal the average fuel cost in an open-hearth furnace using 450 lbs. of coal per gross ton of steel is $1.00. This corresponds to using 38.6 gals. of fuel oil costing in the furnace $3.09. The equivalent amount of coke-oven gas is 9818 cu. ft. costing (at 25 cts.) $2.55.

Heating Furnaces

Producer gas made in modern Morgan machines including all costs of gasification—						
Coal per net ton of billets heated, pounds	100	125	150	175	200	225
1,000,000 Btu. in furnace	1.200	1.500	1.800	2.100	2.400	2.700
Average cost with coal at $2.50 per net ton	$0.158	$0.198	$0.237	$0.277	$0.317	$0.356
Average cost with coal at 3.75 per net ton	0.221	0.276	0.331	0.386	0.442	0.497
Average cost with coal at 5.00 per net ton	0.283	0.354	0.425	0.496	0.566	0.637
Gas from 1 lb. coal = 12,000 Btu. in furnace.						
Cost of equivalent Btu. in fuel oil—						
At 8 cts. per gal. delivered to furnace including cost compressed air, piping, etc., (equal to $13.00 per ton for coal).						
One gallon oil. = 140,000 Btu.						
Gallons oil	8.6	10.7	12.9	15.0	17.2	19.3
Dollars	0.69	0.86	1.03	1.20	1.37	1.54
Cost of equivalent Btu. in coke gas—						
At 26 cts. per 1000 cu. ft.						
Gas from 1 lb. coal = 21.8 cu. ft. coke gas at 550 Btu. per cu. ft., (equal to $11.34 per ton for coal).						
Cu. ft.	2180	2725	3270	3815	4360	4905
Dollars	0.57	0.71	0.85	1.00	1.14	1.28

At the Hamilton plant of the Steel Company of Canada, 1¾-in. square steel billets 30 ft. long are heated continuously with producer gas consuming an average of only 93 lbs. coal per net ton of billets while the Bethlehem Steel Company at Sparrows Point do the same work with producer gas from 109 lbs. coal. Other data covering the same work range up to 158 lbs. per ton depending principally on the tonnage heated.

From the above study it appears that after making full allowance for all expenses of gasification and paying $3.75 per ton for coal the average fuel cost in a heating furnace using 150 lbs. of coal per net ton of steel heated is 33 cts. This corresponds to using 12.9 gals. of oil costing in the furnace $1.03. The equivalent amount of coke gas is 3270 cu. ft. costing (at 26 cts.) 85 cts.

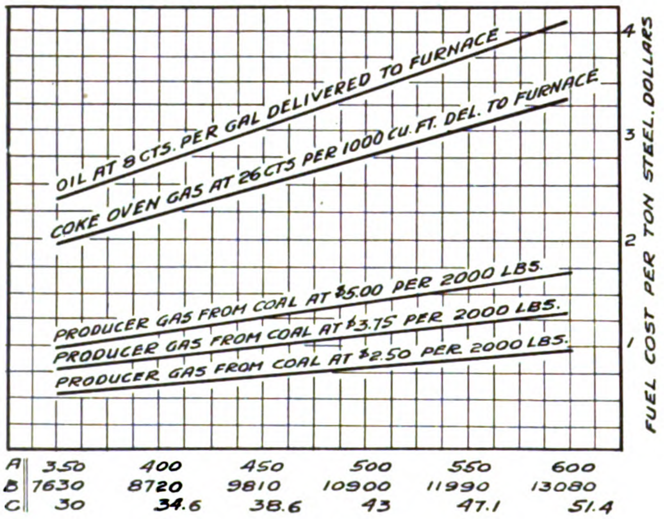


FIG. 1—Comparison of fuel cost per ton of steel melted in open-hearth furnace.

A—Pounds of coal per ton of steel.
B—Cubic feet coke oven gas per ton of steel.
C—Gallons oil per ton of steel.

Producer gas—Includes all costs of gasification, unloading and crushing coal, etc.*

Coke oven gas—Delivered to furnace.

Oil—Includes all cost of oil, pumping, heating, compressed air for atomizing, etc.

Addendum—Heat in Gas from 1 Net Ton of Coal Put Into Open-Hearth Furnace

With an average of 13,500 Btu. per lb. of coal (as given by Y.S.&T.Co.) the total heat in 1 net ton is 2000 × 13,500 = 27,000,000 Btu.

Taking the average analysis of the gas as furnished by the Y.S.&T. Co., namely:

	Per cent
CO_2	4.2
Illuminants	0.62
CO	24.9
CH_4	3.3
Hydrogen	13.9
Nitrogen	53.08

we deduce the following values:

Weight of 100 cu. ft. of gas, 6.52 lbs.
Weight of carbon in 100 cu. ft. of gas, 1.066 lbs.
Combustible value per cu. ft. of gas (at 60 deg. F.) = 158.67 Btu.

Coal analysis (Y.S.&T.Co.):

	Per cent
Fixed carbon by weight	57.36
Volatiles by weight	33.60
Ash and sulphur, weight	9.04

As the volatiles contain about 60 per cent carbon (Bulletin No. 22 U. S. Bureau of Mines) we have total carbon in 100 lbs. of above coal 57.36 + (.6 × 33.6) = 77.52 lbs. We lose about 3 per cent of the coal by soot and dust in the flues, consequently we have only 77.52 — 3 = 74.52 lbs. carbon in the gas from 100 lbs. of coal, available in the furnace.

Therefore we have 74.52 ÷ 1.066 = 69.9 cu. ft. gas per lb. coal (at 60 deg. F.) and the total heat value in the gas from 1 lb. coal = 69.9 × 158.67 = 11,091 Btu.

But producer gas reaches the checkers of the open-hearth furnace at about 800 deg. F. hence we must add its sensible heat at that temperature in order to compare it with other fuels which reach the checkers cold.

(Continued on page 1453)

---

*Coal price is F.O.B. gas house.

Digitized by Google Original from UNIVERSITY OF MICHIGAN

Sheet Steel for Automobile Bodies

A Review of the Various Methods Employed in Testing Sheet Steel — Ductility, Hardness and Tensile Tests Are Compared with the Results of Microscopical Examinations

"AUTOSHEET"

PART IX

IN following the progress of sheet through the mill we have investigated, up to this point, the physical, chemical and microscopical changes which have taken place after the most important operations.

Through the metallurgical department these thermal and mechanical processes have been so arranged as to give to the sheet certain properties best suited for the part intended. Thus cold rolling has imparted surface to the sheet, pickling its cleanliness, chemical analysis and heat treatment its softness and ductility.

This series of articles, appearing under the name of "Autosheet," will be published in book form as soon as the series is completed.

In order to maintain a "spot check" on the various types of processing most sheet mills maintain a testing laboratory, wherein various physical and microscopical tests are made to determine if the properties of the sheet are suitable for the order. These suitable properties are usually determined only after experience with the working of the steel in the presses and a comprehensive understanding of these properties is usually derived only after a similar steel has been pressed to a corresponding shape. The manufacture, properties and action of the sheets in the press are so co-related that the failure to understand one factor makes all other factors practically worthless.

The methods of testing sheets vary over a wide range and in most cases are selected, based on the consideration as to whether the tests are made against production or research, or both. In most cases production is the main factor with the financial expenditure for research testing equipment secondary in importance.

Ductility

In the event of the former reason we must first consider the most rapid and inexpensive method assuring us of a fairly accurate check test, which in turn is dependent on labor and equipment available.

Our first test whereby fair accuracy and rapidity of testing is assured is in the "cupping test" made on either the Olsen or Erickson machines both of which work on the principal of pushing a round steel ball or punch against a small piece of the sheet gradually cupping it until the resulting depression breaks. The depth of this depression is measured in inches on the Olsen and millimeters on the Erickson. These machines are inexpensive, accurate for all commercial productive testing and depict not only the comparative ductility of the sheets but the grain size of the material as well. This latter point can be noticed in the visual examination of the resulting dome of the cup whose surface will vary from a coarse grained "orange peel" effect with a jagged fracture to a smooth cup with the fracture fairly even completely around it.

To illustrate this condition Fig. 1A shows the resulting dome of a sheet whose cup was very shallow (low ductility). The coarse grained or "orange peel" effect seems to indicate large grains, a fact substantiated by Fig. 1B. Fig. 1B is a longitudinal section of the same sheet, polished, etched and magnified 100 times and bears out the fact that the sheet is large grained probably caused by its annealing. It can readily be imagined that its low ductility prohibits any marked drawing in the press. If pressed without breaking any resulting sharp corners or radii will show practically the same surface as this cupped sample.

In a like manner we find that as the grain size of the sheet decreases so does the grainy appearance of the cup as illustrated in Figs. 2A-2B, 3A-3B, 4A-4B, and 5A-5B, all of which are later discussed. While 1A-1B are practically worthless for deep drawing shapes, 2A-2B may be used on parts or shapes requiring very little drawing. Figs. 3A-3B are typical box annealed deep drawing sheets, 4A-4B represent carefully box annealed extra deep drawing sheets and 5A-5B indicate the structure of a normalized and annealed sheet whose surface and depth of draw are excellent for most any stamped shape. This latter case helps to emphasize the point that consumers of sheet steel are demanding a normalized sheet for they are not only

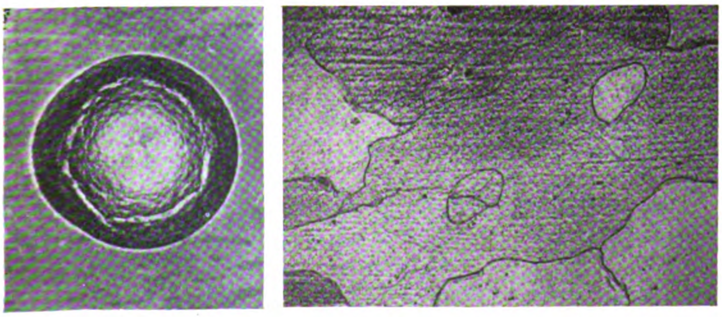


FIG. 1A (left)—Cup test of course grained deep drawing sheet XI. FIG. 1B (right)—Microphoto of Fig. 1A. X100. HNO_3 etchant.

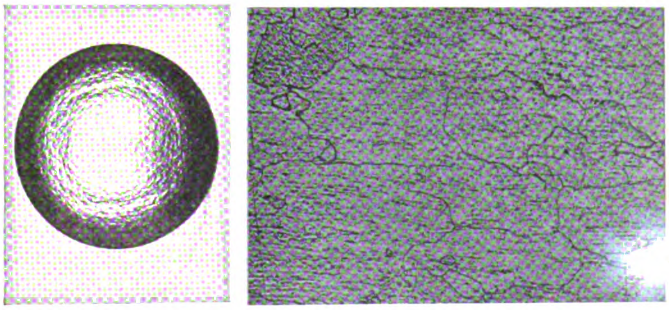


FIG. 2A (left)—Cup test of grained deep drawing sheet XI. FIG. 2B (right)—Microphoto of Fig. 2A. X100. HNO_3 etchant.

Digitized by Google Original from UNIVERSITY OF MICHIGAN

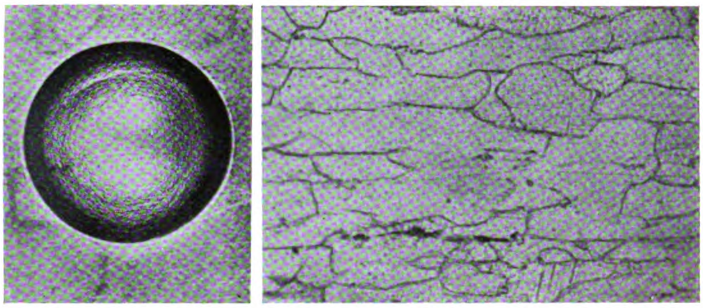


FIG. 3A (left)—Cup test of slightly grained deep drawing sheet XI. FIG. 3B (right)—Microphoto of Fig. 3A. X100. HNO_3 etchant.

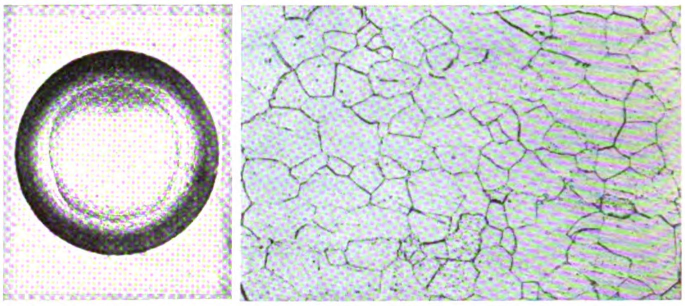


FIG. 4A (left)—Cup test of slightly grained extra deep drawing sheet XI. FIG. 4B (right)—Microphoto of Fig. 4A. X100. HNO_3 etchant.

assured of low breakage but a smooth surface after drawing as well.

Hardness

The next physical test in order of its importance to auto sheet is the use of equipment whereby the hardness is determined. Hardness of sheet steel is usually expressed by arbitrary numbers which are relative only. The hardness may come from the carbon content of the steel which for our low range in sheets will increase fairly proportionately with increasing carbon content or it may come from the amount of cold rolling the sheets receive in their processing, the hardness increasing with cold rolling.

The outstanding hardness tester for dead soft sheet steels is the Rockwell machine. With sheets of .05 per cent to .15 per cent carbon content we would use a 1/16-in. ball which, by means of certain leverage and a 10 kilogram (minor) load, will first push this ball through the outer surface of the sheet. After the application of this minor load a 90 kilogram (major) load is applied and the ball depresses itself further into the steel. The minor load is then released and the difference in depth to which the major and minor loads were depressed is expressed by an arbitrary number read on a directly recording scale attached to the leverage system. Only a small section of the sheet is used, the test is very rapid and requires no experience or skill. This machine seems to be the most satisfactory as it will handle thin sections of dead soft material such as auto sheet with fairly accurate results.

The Brinnell hardness tester is, therefore, out of the question at this point as it employs greater loads, is slower to read and for thin dead soft stock such as sheets a portion of the hardness would come from the steel anvil on which the sheet rests. Super-imposing two or more sheets to offset the hardness caused by the resistance of the supporting anvil, will bring in errors such as a possible slippage and further resistance by air gaps if the sheets are not perfectly flat.

Hardness by means of the scleroscope tester means little to us in testing automobile sheets as this method of testing is based on the resilience of the sheet only. Such tests would show extreme variations due to different surface finishes given to the sheet after its annealing. Thus hood and fender and radiator sheets may receive several passes in the cold rolls as their finishing process, the draft on the rolls varying from time to time to correct the surface pressure and to eliminate cold rolling defects. This fluctuation in draft causes a variable surface hardness and thus, in spite of established scleroscope standards, the readings will vary over a wide range. Furthermore in spite of the varying scleroscope readings in one, two or even three cold roll passes the drawing characteristics of the sheet are practically unchanged which is after all our prime consideration. In another interpretation, surface finish is more visual than physical and we are primarily interested in the drawing of the sheet as much if not more than in its surface derived from cold rolling.

Tensile Strength

Thus far we have briefly described the advantages of ductility and hardness as not only a rapid but also a fairly accurate check on the general run of steel. These tests should be and are maintained in practically every sheet mill and serve in their small but still important way to maintain the quality of the outgoing product. The extent to which test samples are taken will vary in different mills. In some cases ductility and hardness tests taken after normalizing or annealing are the criterion while other plants derive testing data from the order after its process has been fully completed. The number of test sheets secured will run from one or two sheets from the order to as many sheets from each pile in the order. The number of tests will naturally vary depending on the attitude of the company towards a close scrutiny for quality and indirectly the labor available to rapidly secure and determine these tests.

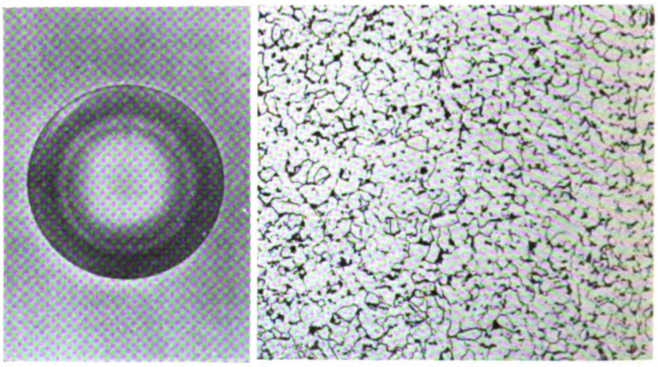


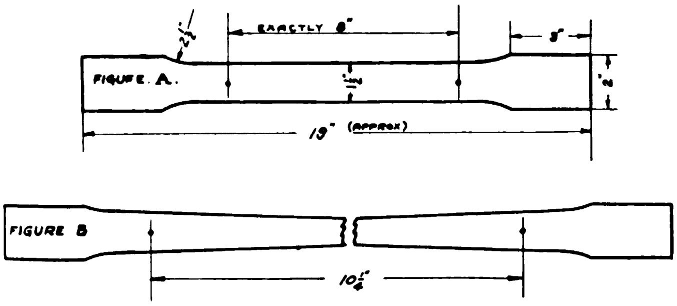
FIG. 5A (left)—Cup test of slightly grained normalized and annealed sheet XI. FIG. 5B (right)—Microphoto of Fig. 5A. X100. HNO_3 etchant.

Assuming that these two modes of testing, already discussed, are made rapid, we may now have more time and space for other testing equipment which brings up the question as to what data is next in importance for determining the properties of sheet steel. Opinions may differ at this point but it is the author's contention that microscopic examination is next in

Digitized by Google Original from UNIVERSITY OF MICHIGAN

importance followed by tensile strength data. The use of microscopic equipment calls for the services of a metallographist who can polish, etch and interpret the grain structure of the steel thus revealed. All of this calls for extensive equipment and time but it is unquestionably worth it. However before discussing further this phase of testing let us consider the importance and manner of taking tensile strength tests concluding the list of the most important means of physically testing sheet steel.

The tensile strength of sheet is essentially the maximum load per unit of original cross sectional area that the sample will withstand before rupture. In making such a test we can also readily determine from the same sample the per cent elongation which is another means of specifying its ductility. This per cent elongation is defined as the per cent increase in length of the specimen after the rupture. Careful manipulation of the machine during the test will also allow the determination of the elastic limit or yield point at which point the external strain applied to the sample exceeds the internal resisting stress. In this change the atomic bonds of the sheet are broken and seek new bonds with other atoms. The release of the tension or pull of the machine after this elastic limit has been exceeded will not allow the sheet to resume its original shape. Sketch I shows a typical tensile sample before and after its rupture. Tensile tests can be made on either the Riehle, Olsen or other testing machines, the data from which can be made extremely useful if correctly interpreted. For example it has been found that in the study of elastic limit alone this property greatly influences the working of sheet in the press. Experiments have proven that the higher the elastic limit the better the steel seems to draw in the press, assuming all other factors constant for the moment. This may be better understood from the tensile strength data as set forth in Table I.



Sketch I—Typical tensile strength tests on 20 gage deep drawing sheet steel.

Dimensions of Sample.

	Before pull	After pull
Figure	A	B
Length, inches	8	10¼
Thickness, inches	.0375	.031
Width, inches	1.50	1.19
Cross section area, square inches	.05625	.0369

Scale at elastic limit = 2100 pounds.
Scale at ultimate strength = 2570 pounds.

$$\text{Tensile strength} = \frac{2570}{.05625} = 45{,}688 \text{ lbs. per sq. in.}$$

$$\text{Elastic limit} = \frac{2110}{.05625} = 37{,}511 \text{ lbs. per sq. in.}$$

$$\text{Elongation in 8 inches} = \frac{10.25'' - 8''}{8''} = 28.1 \text{ per cent.}$$

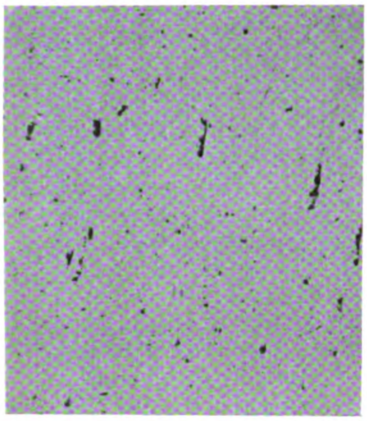
$$\text{Reduction of area} = \frac{.05625'' - .0369''}{.05625''} = 34.4 \text{ per cent.}$$

Briefly, the sample to be tested in either of these machines is carefully measured for an average cross sectional area between the punch marks exactly 8 in. apart (see Fig. A). The sample is then clamped into the machine in a vertical position, the upper section of the sample set in stationary jaws with the lower section in a movable jaw, through which a vertical pull is exerted on the sheet by means of a worm drive pulling the piece at the rate of about one-quarter inch per minute. This external pulling force is recorded in pounds on a graduated beam of the machine the weight on this beam balancing the pulling force at all times. As the sample elongates the weight travels at a uniform rate out on the scale, thus indicating that the sample is obeying the law of stress and strain. However a point is reached on the scale where for a moment, the beam drops denoting an elongation in the test piece without any increase in the load. This point is recorded and is known as the yield point or elastic limit. The load very shortly causes the beam to rise and the pulling continues although less uniform than before. Soon the beam drops for the second and last time indicating that the ultimate tensile strength of the sheet has been reached. This load is recorded and the machine continues to elongate the specimen which for the general run of sheet steel is very pronounced at this point. Finally the sheet ruptures, is removed from the machine and the two sections are pieced together for the measurement of the distance between the original and final punch marks which as figured in Sketch I gives us the per cent elongation in 8 in. The calculation of the tensile strength, elastic limit and reduction of area are also included in this table and are self explanatory.

The foregoing comparison of the various physical tests and their relative importance to the general testing of sheet steel brings to a close interesting facts and in Table I, interesting figures. This table shows hardness, ductility and various tensile strength tests which indicate, to a certain extent, the trend of the various physical properties when influenced by annealing followed by the customary slow cooling in the pots to atmospheric temperature. (Note samples 2 to 5 inclusive in Table I.)

Microscopic Observations

While these physical tests show certain relations or comparisons between themselves they do not always take into account the reasons for breakage of the sheet in the press. For example, the several physical records of an order may be identically the same and within the range of good testing yet heavy breakage may be encountered. This breakage cannot be accounted for except by a microscopic examination of the structure of good and bad sheets for internal defects. These defects may be slag and dirt inclusions, segregation of phosphides and sulphides, variation in grain size and insufficient annealing. In all probability one or more of these defects, thus microscopically revealed, will satisfactorily explain the reason for the breaking of the steel in the press while the available physical data in itself might be worthless. On the other hand unusual variation in physical properties are often accounted for in micro-structural studies. (See samples 4, 5, and 6.)



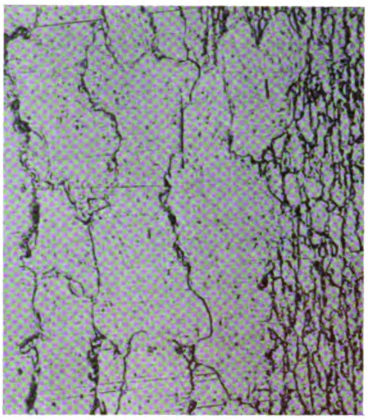


FIG. 6 (left)—Unetched specimen showing slag inclusions. X100. FIG. 7 (right)—Sheet showing grain growth and underannealing. X100.

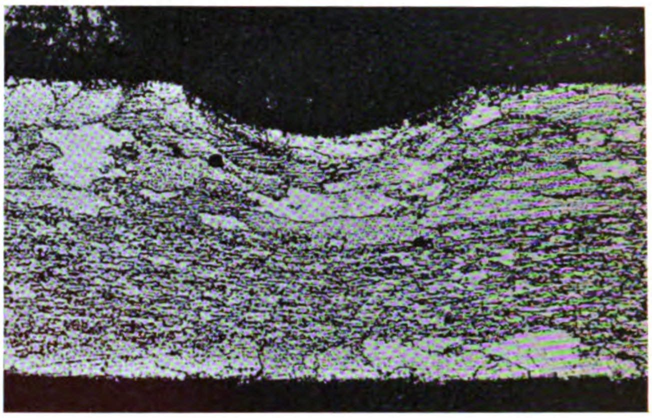


FIG. 8—Sheet showing grain growth and underannealing. X40. With Rockwell impression.

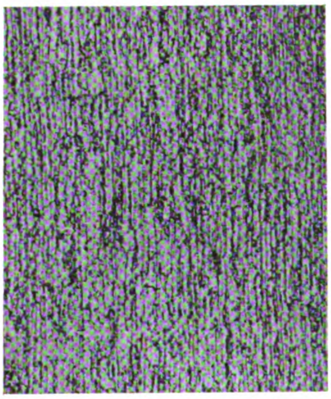
Thus the importance of the microscope, when used in conjunction with physical tests, is becoming more apparent and appreciated. While the micro-structural study requires laborious preparation of the samples and highly technical men for their correct interpretation, it should be evident that the expenditure necessary is well repaid to those who demand a uniform product.

Briefly the manipulations of microscopic testing include the mounting of the sample in a holder usually so that the longitudinal side of the sheet is polished. Polishing is accomplished by grinding on fairly coarse alundum or carborundum wheels or belts for a flat surface, rough polished on emery paper then fine polished on two or more still finer emery papers. This is followed by a polish on broadcloth with levigated alumina suspended in water keeping the cloth moist. Between each one of these polishing steps the face of the sample is turned 90 deg. and ground until the scratches from the previous grind have been obliterated. The polished sample is washed in water, then alcohol and thoroughly dried in a warm blast of air.

If the polished samples are now placed under the microscope, any inclusions such as slag, dirt and nonmetallic inclusions might be macroscopically noticed. Fig. 6 illustrates such a case, the dark spots indicating non-metallic inclusions which appear to be slag in the original negative.

However we are more interested in the grain size and distribution of the constituents as revealed by the slight corrosion or etching of this polished surface by weak acids. For low carbon sheet steels the etching is very rapid, the weak acids attacking certain constituents more rapidly than others. The acids most common for etching sheet steel are either picric or nitric dissolved in alcohol to about a 5 per cent concentration. The polished section is immersed in either of these acids from 5 to 30 seconds, depending on the constituents present in the sheet and their response to the acid with the picric acid usually taking the longer time to etch. The acid is then removed by washing and then dried in alcohol followed by a warm air blast and the sample is now ready for study and interpretation. The usual magnification is 100 diameters or by the expression X100.

Fig. 1B substantiates the large coarse grained surface of the cupping test (1A) in that the grains are very large due, in all probability, to over annealing. Fig. 2B also shows grain growth but less pronounced (also note cup test 2A). Fig. 3B shows a fair deep drawing (cup test 3A) and while the physical data (sample 2, Table I) show fairly good results, the microscope reveals that the anneal has not been sufficient to completely relieve the strains set up by hot rolling with the result that the grains are still slightly elongated in the direction of rolling. Note the slag inclusion in this microphoto. Fig. 4B microscopically reveals an equi-axed grain structure of an extra deep drawing sheet wherein the annealing has relieved all strains and set up, in its slow cooling, fairly uniform grain structure. (Note physical properties in sample 3, Table I and cupping test in Fig. 4A.) In Fig. 5B we have a normalized and annealed sheet in which the normalizing has been well carried out giving us a uniformily small grain highly desirable for difficult sheet stampings. The anneal which followed has not been high enough to cause grain growth and the physical properties of sample 1, Table I, along with this photo, bear out the structure thus revealed.



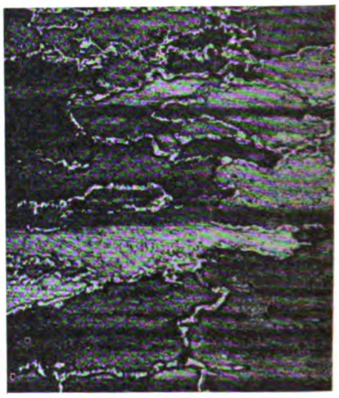


FIG. 9 (left)—Sheet showing underannealing with original hot mill strains. X100. FIG. 10 (right)—Sheet showing phosphide segregation—Stead's reagent. X100.

The most common structural defects quite often bear out our physical data and as previously mentioned, are reviewed in samples 4, 5 and 6 of Table I. In sample 4 we find a sheet which shows a grainy surface but a fairly high tensile strength, low elastic limit, elongation and ductility. The hardness is, however, unusually low.

In Fig. 7 this sheet microscopically shows the effect of a rash heat in the annealing thus causing grain

Digitized by Google Original from UNIVERSITY OF MICHIGAN

TABLE I—COMPARATIVE PHYSICAL AND MICROSCOPICAL TEST ON SHEET STEEL.

Sample	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Tensile strength ..	47,600	42,710	39,700	49,500	53,700	37,400
Elastic limit	36,300	20,040	25,400	27,600	19,850	23,900
Elongation in 8"...	32.9%	25%	30.5%	25.1%	17.8%	26.4%
Reduction of area..	43%	34.5%	38.5%	30%	29%	39%
Olsen ductility	.417"	.369"	.385"	.344"	.325"	.375"
Cup test and photograph No...	5A	3A	4A	1A	2A	2A
Surface of cup.....	Very slight grain	Grain	Slight grain	Grain	Slight grain	Slight grain
Rockwell hardness.	B45	B42	B38	B33	B59	B39.5
Microphotograph ..	5B	3B	4B	7 and 8	9	10
Etchant	Nitric	Nitric	Nitric	Nitric	Nitric	Stead's
Description of sample	Normalized and box annealed	Fair deep drawing box anneal	Good extra deep drawing box anneal	Grain growth with poor annealing	Under-annealed	Phosphide Segregations
Breakage in press*.	1%	7%	3.5%		100%	25%

*Pressed into rear side for coupes.
All magnifications of longitudinal section X100; unless otherwise specified.

growth near the surface, evidenced by the cup test. The soaking period has evidently been short as small strained crystals appear near the center of the sheet which might account for the high tensile, low elastic limit, elongation and ductility. To account for the relatively low hardness we present Fig. 8 which shows a larger area of the same sheet etched and magnified 40 (X40) times. This figure shows the depression made by the small steel ball of the hardness tester and indicates that the low hardness number was derived from the ball penetrating only a few large ferrite grains which in themselves were very soft and ductile. Had the ball penetratd to the unannealed portion near the center of the sheet it necessarily would have had to move smaller and harder grains, thereby decreasing the depth of penetration and indirectly raising the hardness number.

This example brings to our attention Fig. 9 showing a sheet whose anneal has been too low to relieve even the hot mill strains with practically no refinement of grain. The physical properties in sample 5, Table I, bear out our microscopic conclusions and is included to illustrate the importance of the anneal which must have a soaking heat distributed to all portions of the pile of steel in the box. Such a sheet as shown in Fig. 9 might readily come from sheets near the bottom central part of a box annealed in a fast rash heat with no time for soaking.

We will conclude our discussion of microscopical defects with a brief study of Fig. 10 which illustrates the presence of phosphides around the grain boundries thus causing extreme brittleness and high breakage in the press. To bring out these impurities it was necessary to etch the specimen with Stead's reagent which is essentially copper chloride in alcohol. When this reagent is rubbed over the specimen three or four times copper precipitates on the pure sections (ferrite and pearlite) leaving the phosphides exposed. In this example the phosphides follow the grain boundaries, in some cases completely surrounding them and preventing their flow when drawn. Physical data accompanying this sample (sample 6) show fair tests and it was necessary to microscopically examine this sheet before definite conclusions could be reached as to the cause of breakage.

Without question this sheet came from a bar cut too close to the top or "pipe" of the ingot. Due to the natural laws which govern the solidification of liquid metals, certain constituents such as phosphorus and sulphur are last to solidify, and are thus found to be more or less segregated near the top of the ingot which we call the "pipe." While good mill practice allows for cropping of the worst of the "pipe" it quite often happens that too little is cropped resulting in a good many sheets going out which invariably show breakage due to the presence of these impurities.

Conclusions

To briefly summarize this particular discussion it appears that the most rapid and accurate tests for sheet steel are found in the Erickson or Olsen ductility testers and the Rockwell for hardness.

These tests are sufficient if only to maintain "spot checks" on the general run of steel but where a closer and more dependable check is demanded microscopical examination for uniformity of grain and the presence of structural defects is practically a necessity if uniformity is desired.

Tensile strength data are worthy tests but like the ductility and hardness tests are dependent on structural examination for their comprehensive understanding. The relation of all tests whether microscopic or physical must be co-related with the action of the sheet in the press.

(To be continued)

Relative Cost and Value of Fuels

(Continued from page 1448)

Computed by the U. S. Steel Company method for obtaining the sensible heat we have:

$$.0652 \times 69.9 = 4.56 \text{ lbs. gas per lb. coal}$$

Specific heat at 800 deg. F. = 216.2 Btu. per lb. of gas

$$\text{Sensible heat in gas per lb. of coal} = 216.2 \times 4.56 = 986 \text{ Btu.}$$

Hence total heat reaching open-hearth furnace checkers, 11,091 + 986 = 12,077 Btu. per lb. coal or 12,077 × 2000 = 24,154,000 Btu. per ton of coal. The Y.S.&T.Co. state that their coal averages 13,500 Btu. per lb. = 27,000,000 Btu. per net ton. This computation, based on the average gas analysis, shows an efficiency of 89.46 per cent after allowing 3 per cent waste in flues.

Design and Operation of Strip Mills[*]

Descriptions of Mills and Their Development Are Here Given with Information Concerning Production and Products — Furnaces and Devices for Charging and Drawing Billets

Translated by R. W. DEIMEL[†]

PART II[‡] and PART III[§]

THE evolution of the strip mills of the firm of Theodor Wuppermann took place along the following lines: During 1888 a 300 mm (11.8-in.) rod mill was remodeled for rolling strip. This mill comprised seven stands, the rougher being included in the strand. Rolling took place in grooves, in the well-known way, same as during decades afterwards, until the excessive number of widths which were demanded forcibly brought about the introduction of edgers. The widths ranged from 13 to 105 mm (.511 to 4.13-in.).

The broadening demand in narrower strip prompted, during 1893, the construction of a 260 mm (10.24-in.) mill, with separate roughing stand. The finishing train comprises 7 stands. Later the polishing stand was taken out, driven by special motor and fitted with rolls of larger diameter, with a view to increase production and improve on the finished product as regards accuracy of dimensions and outside appearance. For raw material billets of 50 to 60 mm square (1.97 to 2.36-in.) were used, to roll strip 8 to 45 mm wide (.31 to 1.77-in.) and down to .8 mm (.031-in.) gauge. Both mills were served by a double semi-gas fired furnace.

Consumers' requirements became more exacting, and so, in 1900, a 350 mm mill (13.78-in.) and a 450 mm mill (17.72-in.) were erected (see Figs. 1 and 2) which were placed on parallel lines and driven by one engine. Both trains had each five stands, and the rougher was included in the strand. The layout permitted of only one mill being operated at a time, and the length of the stock was limited. This plant was also served by a semi-gas furnace. Bands of 50 to 305 mm (1.97 to 12-in.) wide were produced.

New Mills Follow Demand for Strip

The ever increasing demand, and stricter requirements in quality, also in length and width necessitated the installation of a 500 mm (19.68-in.) mill, which was placed in operation in 1914. By the building of this mill the 450 mm mill was superseded. It was therefore dismantled but for one stand, which was used as rougher for the 350 mm (13.78-in.) mill. During later years this mill was made automatic as far as possible. A roller run was placed between roughing and finishing stand, so that the stock issuing from the rougher entered automatically into the first finishing stand. The strip drops, back of the rolls in the two following stands, onto a roller run, is automatically handled into the rolls and back by means of a Quast & Lomberg repeater, receives a hand pass, is then looped from stand to stand by a Schoepf repeater, travels over a roller reverse run and again through repeaters. The finishing pass is made by hand. Owing to the rapid passage of the stock through the mill it was possible to improve considerably on the rolling, and above all to attain a better and more uniform product. The mill crew could be reduced by 70 per cent. For raw material billets of 60 to 100 mm (2.36 to 3.94-in.) or small slabs up to 120 mm wide (4.72-in.) are used, rolling strip 60 to 125 mm (2.36 to 4.92-in.) wide.

The 500 mm (19.68-in.) mill (see Fig. 3), which was placed in operation during 1914, has a roughing train of three stands in tandem, followed by four double duo stands arranged in an open finishing strand. For raw material slabs from 150 to 400 mm (5.90 to 15.75-in.) wide and 80 mm (3.15-in.) thickness, weighing up to 275 kilos (600-lb.) and billets up to 115 mm (4.53-in.) square are used, depending on the desired width of the band. The mill is served by a semi-gas furnace. The furnace shed is equipped with two magneto-cranes, which also serve the billet yard by means of an outside track 125 meters (380 ft.) long. On the opposite side of the furnace shed are located the billet shears for the smaller mills, which are also served by the magneto cranes. A 25-ton erection crane is provided for placing the ready assembled double duo stands into position. The stock passes through the three roughers and the first stand in the open strand, after which the flat, by means of a kick-off, is thrown from a table into a trough, there turned up on edge, then by vertical pinch rollers pushed into the edger, on the other side handled upwards against a horizontal pinch roller, by means of a lifting table and back into the rolls. Further moving, back of the rolls, is done by drags. A repeater is placed before the rolls. The polishing pass is made by hand. Attempts to make this pass automatically have been discontinued on account of trouble with the thinner gauges. However trials will be resumed.

The finished stock is made up either in cut lengths or in coils. The bands are picked up from the run-out by means of a patented device, and piled up for soaking. The packs are taken to the shears by drags.

Experience gained in the operation of this mill had the result that the first stand was made an edger, when more mills along the same lines were erected by other firms. Through the edging pass and a blower the scale was removed as good as completely from the slabs, and the raw material question was much simplified. The range of width of slabs required for the various strip dimensions can be reduced to a few sizes, since the edger takes care of the intermediate sizes. An edger of this kind will also be installed in the mill described, on which strip from 85 to 400 mm (3.35 to 15.75-in.) wide is produced. Depending on sizes, productions of 80 to 140 tons in 10 hours are attained.

---

[*] Reports 60 and 61 of the Rolling Committee of the Verein Deutscher Eisenhuettenleute.

[†] From Stahl und Eisen.

[‡] Strip mills of the firm of Theodor Wuppermann, at Schlebusch-Manfort, by Direktor C. Schulz at Schlebusch-Manfort. (Report 60.)

[§] Strip mill of the Bochumer Stahlindustrie, by Direktor Dipl. Ing. H. v. Avanzini of Bochum. (Report 61.)

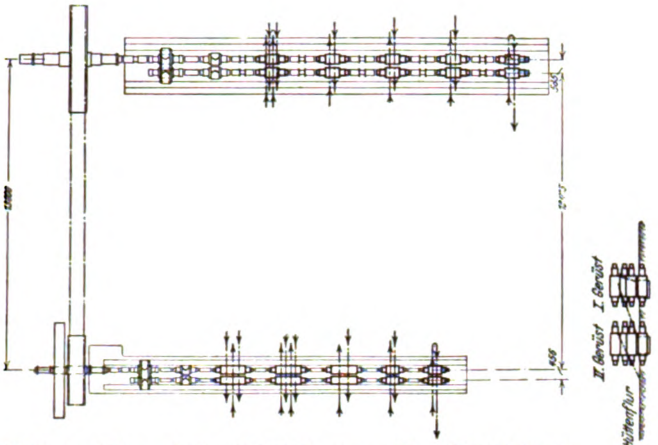


FIG. 1—Plan of the 350/450 mm mill (13.78/17.72").

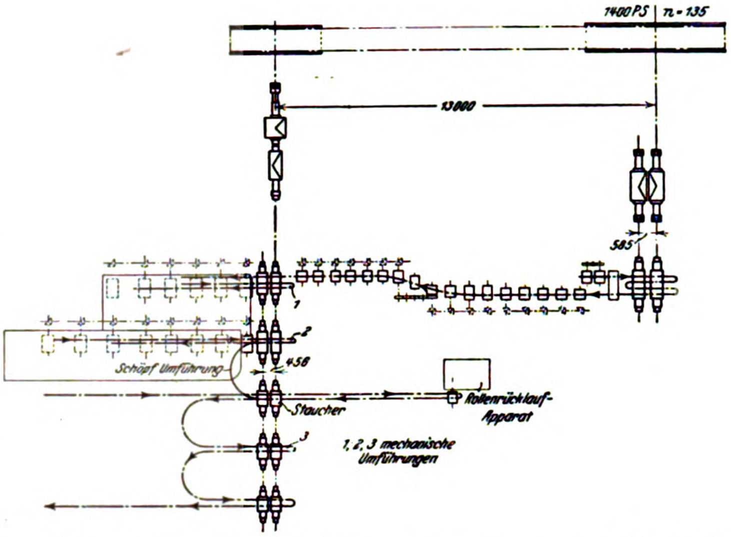


FIG. 2—Plan of the 350/450 mm mill. I. geruest—first stand; II. geruest—second stand; Schoepf umfuehrungen—Schoepf repeaters; staucher—edger; 1, 2, 3 mechanische umfuehrungen — mechanical repeaters; rollenruecklauf apparat — roller reverse apparatus.

Requirements of consumers, in lengths and accuracy of sizes, becoming more stringent from year to year, and with the necessity of meeting them, another mill was placed into operation during 1924, the average diameter of rolls being 280 mm (11.02-in.). The principle object of this mill is to roll long bands, and to further reduce the thickness, making as little use as possible of the permissible tolerances. The mill is driven by a regulation unit grouped in the well known way: a.c. front motor, d.c. rear motor and transformer. The number of revolutions is variable from 140 to 240 r.p.m. The mill comprises one roughing stand, one open strand of 5 housings and three finishing stands in tandem. The intermediate strand is direct driven, the rougher is rope driven and the three continuous stands are driven by bevel gear. The 450 mm (17.71) operates with 3 Schoepf repeaters. From the rougher the stock is delivered to the intermediate stand by a roller run, the strand comprising 5 housings. The first four stands are connected by three Schoepf repeaters. The last pass is hand made, cropping taking place simultaneously. Leaving this train the stock is delivered to the three continuous stands (Schoepf design) which are equipped with roller bearings.

Roller Bearings Practical

The roller bearings (see Fig. 5) have proved very satisfactory during three years of operation. In the beginning some minor alterations had to be made, but today they are beyond reproach. Proper treatment of roller bearings in mill practice is of first importance. When being transferred from one roll to another, the bearing must, completely encased, remain on the roll-neck, taken out of the mill to a dustfree room, and there withdrawn to be placed on the new roll. The rollnecks have shrunk-on

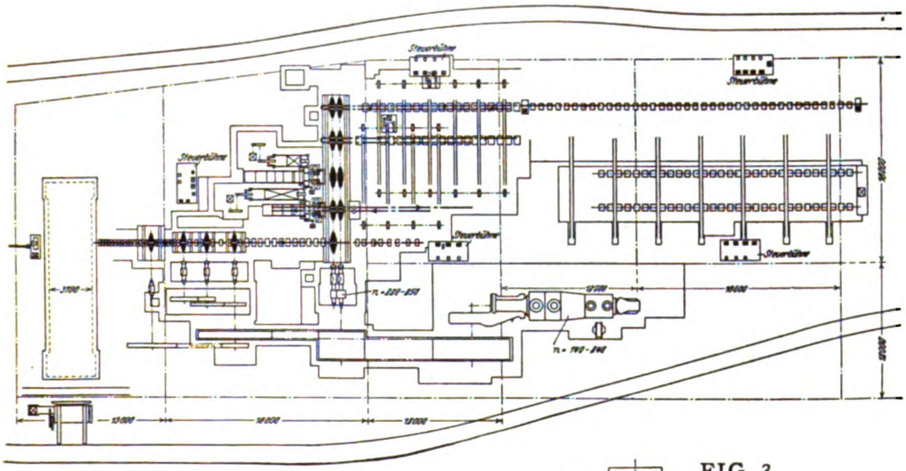


FIG. 3

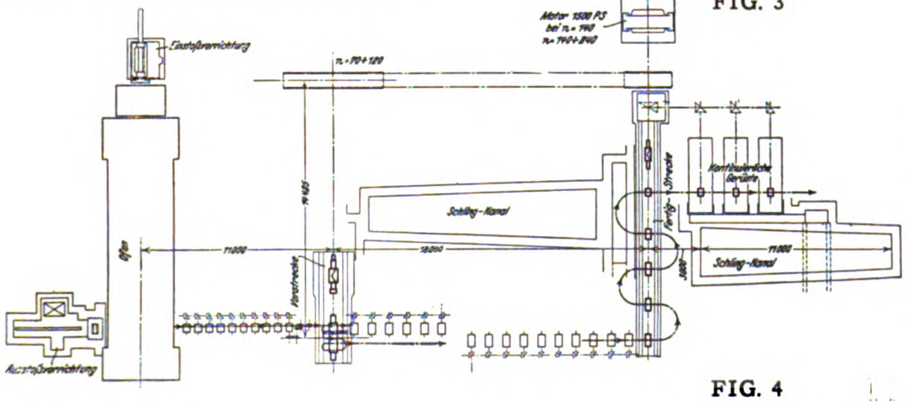


FIG. 4

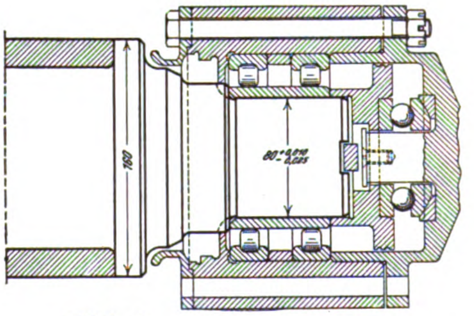


FIG. 5

FIG. 3—Plan of 500 mm mill (19.68"). Steuerbuehne—operator's platform.

FIG. 4—Plan of 280 mm mill (11.02"). Einstossvorrichtung—pusher; ausstossvorrichtung — discharge device; vorstrecke—rougher; schling kanal—sling channel; kontinuierliche gerueste—continuous stands.

FIG. 5—Roller bearing of polishing mill.

special steel bushes which after the roll is worn down can be taken off for further use on a new roll.

The other stands of this mill are equipped with plain bearings, provision having been made so that roller bearings can easily be installed.

Considering that opinions were very much divided at the time being regarding the use of roller bearings, and the many set-backs experienced with this kind of equipment, it goes without saying that a certain time had to lapse before final judgment could be passed. This trial period is over now and more extensive use of roller bearings in this mill can now be planned.

Introduction of roller bearings involves a great change for the rolling mill engineer, who has now to deal with a complicated part of machinery requiring special treatment. The delivery speed of this mill amounts to 10 to 12 meters/sec. (30 to 37 ft.). Tests to ascertain fluctuations in thickness showed, in bands 300 to 400 meters long (900 to 1,200 ft.) and .7 mm (.0276-in.) thickness, deviations of .02 to .04 mm (.000787 to .000157-in.) between the ends. That seems exaggerated, but is explained by the almost complete rigidity of the roller bearings. On this mill strip from 16 to 75 mm width (.629 to 2.95-in.) is produced. The narrower strip can be rolled down to .65 mm (.0256-in.). How the cost of rolling hot strip of this gauge compares with cold rolled strip is a matter of calculation.

Heating Furnaces and Fuels

The mill is served by a furnace fired with powdered lignite. The lignite is supplied ready for application, delivered into a storage hopper at a pressure of 2 atm., drops into a service hopper, which can be shut off, from here into an adjustable screw conveyor which carries it into the way of the blast and into the burners.

It is very difficult to lay down definite lines for the design of strip mills, because the requirements in the make-up and quality of strip vary considerably. It goes without question that straight continuous strip mills can operate economically only if they can produce large quantities of one section. Frequent changes for rolling small quantities influences the production costs very unfavorably, which is less remarkable in case of semi-continuous or open mills. If frequent changes are necessary, and the mill is almost automatic, there are not sufficient men to effect the changes, and there is considerable loss of time. The advantage on one side is made void by the loss on the other. Yet there always remains the improvement in quality and size of the product, due to the higher finishing temperature, which is of special importance for subsequent cold rolling.

Other requirements of consumers for instance make the retention of a runout with cast iron floorplates desirable. The make-up of strip as delivered today is the following:

1—In coils of 100 to 600 mm inside diameter (3.937 to 23.6220-in.).

2—In bridles, mostly demanded by retailers.

3—In bars of various length.

Regarding furnaces in strip mills there is a diversity of opinion about the use of powdered coal. In case billets are rolled, which receive a number of square, oval and other passes, the deposition of slag carried by the flame has no influence on the surface of the stock, because the slag is completely removed during the process. The deposits become more embarrassing when rolling sheet bars or slabs, but here also the difficulties will soon be overcome; there are already burner and combustion-chamber-designs available which, with properly conducted flame, prevent the access of more than negligible particles of slag to the hearth. In order to play safe, a semi-gas fired slab furnace was equipped with a fore-hearth, which was located between stoker and hearth, in order to give the flame a chance to deposit the slag particles which it carries. The design has proved very satisfactory.

The capacity of the German strip mills, estimated on the allotments of the strip combine, is equal to about 1 million gross tons. The employment, including export orders, does not amount to more than 60 per cent of the allotted quantities, which means of capacity.

No doubt strip steel will find an ever broadening range of application, but new outlets must be searched for and found. Members of the strip steel combine have appointed a special committee for this purpose, and it must be hoped that this work is successful. In any case, it will be a long time before the existing strip mills, apart from business conditions in general and seasonal symptoms, will be permanently employed.

Resume

The evolution of the strip mills of the firm of Wuppermann is related and a description given of the mills erected during 1914 and 1924. The roller bearings used in the new mill are specially referred to. Information about the capacity of the new plant is given; economical questions pertaining to the construction of strip mills, requirements of consumers and the range of application of strip steel are discussed.

PART III

Strip Mill of the Bochumer Stahlindustrie

The strip mill (Fig. 6) placed in operation during spring, 1921, at the Bochumer Stahlindustrie, Bochum was designed with the intention to build a mill capable of turning out both special steel and iron in the shape of heavy bands of accurate dimensions. The range of sections comprises bands from 50 to 203 mm wide (1.97 to 7.99-in.). The thinnest gauge for bands 50 to 80 mm (1.97 to 3.14-in.) is 1 mm (.039-in.) for iron and 1¼ mm (.049-in.) for special steel, rising to 1¾ mm (.0689-in.) for iron and 2 mm (.078-in.) for steel in case of maximum widths from 150 to 203 mm (5.90 to 7.99-in.). The coil weights amount to 26 to 127 kilos (57 to 280 lb.) according to section.

The raw material consists of billets 50 mm square (1.97-in.) or flat billets and sheet-bars 60 to 210 mm (2.36 to 8.27-in.) wide by 35 to 40 mm (1.38 to 1.57-in.). The length of the raw material is limited by the furnace dimensions to minimum 1,600 mm (64-in.) and maximum 2,400 mm (94.5-in.).

The stockyard is situated close to the furnace, served by two charging cranes of 5 and 3-ton capacity, which also serve two other mills built beside the strip mill.

Heating Furnace

For preheating the sheet-bars a continuous furnace of the double chamber semi-gas fired type, design Hermann Gasch, was selected. The furnace (Fig. 7)

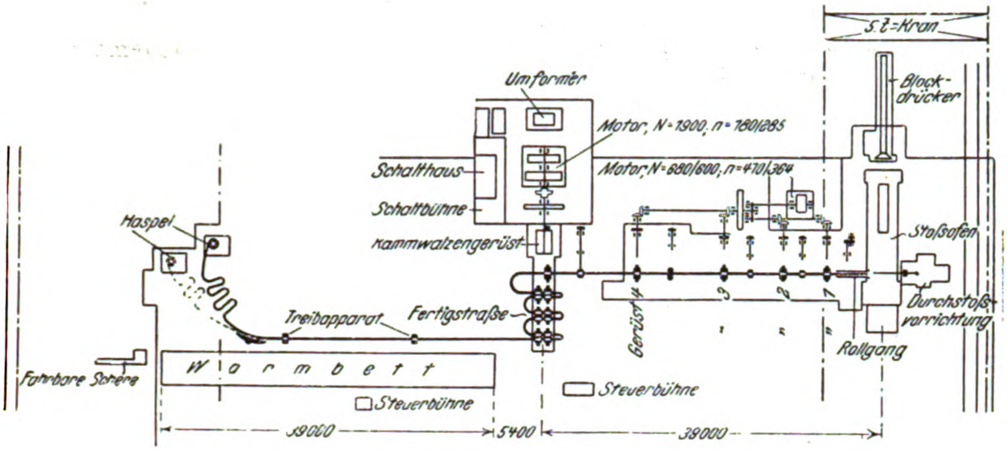


FIG. 6

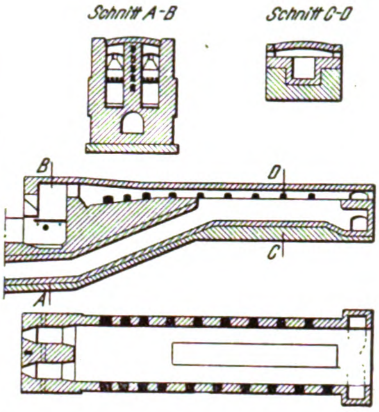


FIG. 7

FIG. 6—Steel strip mill. Fahrbare scheere—portable shear; haspel—reel; wrambett—cooling bed; treibapparat—pinch roller unit; fertigstrasse—finishing train; kammwalzengeruest—pinion housing; schaltbuehne—switch platform; schalthaus—switch room; umformer—transformer; steuerbuehne—operating platform; rollgang—roller run; stossofen—continuous furnace; durchstossvorrichtung—pusher; blockdruecker—ingot pusher.

FIG. 7—Steel strip furnace. Schnitt—section.

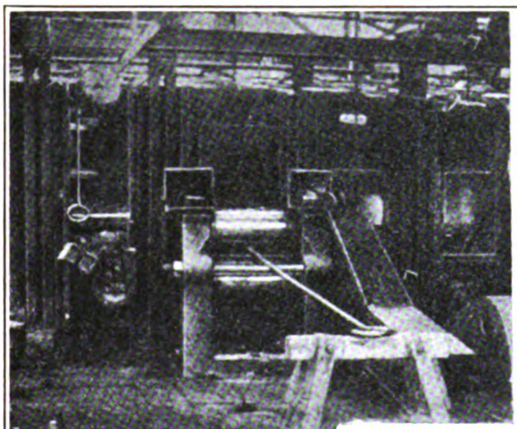
has a total length of 15.8 meters (51.75 ft.) and a width of 2.6 meters (8.5 ft.). The useful hearth area is 12 meters (39.4 ft.) by 2.4 meters (7.85 ft.). Its advantages consist in the favorable design of the combustion chamber and the manner in which the flame is guided.

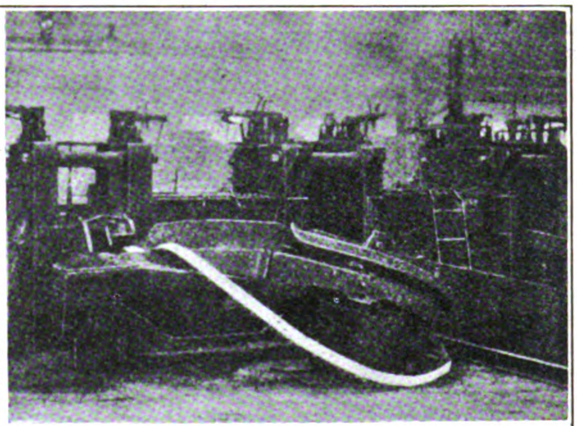
In this type of furnace the waste-gas flue, for two-thirds of the lengths of the furnace and in the direction of its axis, is so designed that the stock to be heated furnishes the covering of the flue. Flames and gases pass first between roof and stock until they reach the charging door, where they are drawn into the flue and pass under the stock towards the stack. Since the sheet-bars or billets are not stacked close together, part of the gases flow through the crevices and take the shortest cut to the waste gas flue. In this way the material is heated on two sides, and part of it on 4 sides, whereby an excellent heat transfer and high furnace efficiency, combined with smallest fuel consumption, is ensured. The furnace has proved very good as regards quality of products and economy. Apart from a great throughput, which amounted up to 132 tons in 10 hours, a coal consumption of average 7 per cent when charging cold stock could be attained, and with a maximum throughput as mentioned before, even 5 per cent. Loss due to scaling amounts to 3½ per cent in case of iron, and abt. 3 per cent for steel. Swing doors were provided at the charging end, in order to prevent inleakage of cold air as far as possible. The stock to be charged is placed on a table in front of the charging door by a magnet crane. The charging proper is effected by a pusher, driven by a motor through an intermediate gear, and operated by a pull cord. In order to attain complete evacuation of the furnace, which is important in case of high grade stock, an arm of 9 meters (27 ft.) stroke was provided.

Considerable attention has been given to tight fitting stoke-hole-and service doors. These doors are

FIG. 8 (left)—Discharging device.

FIG. 9 (right) — Schoepf repeater with cover for strip steel.





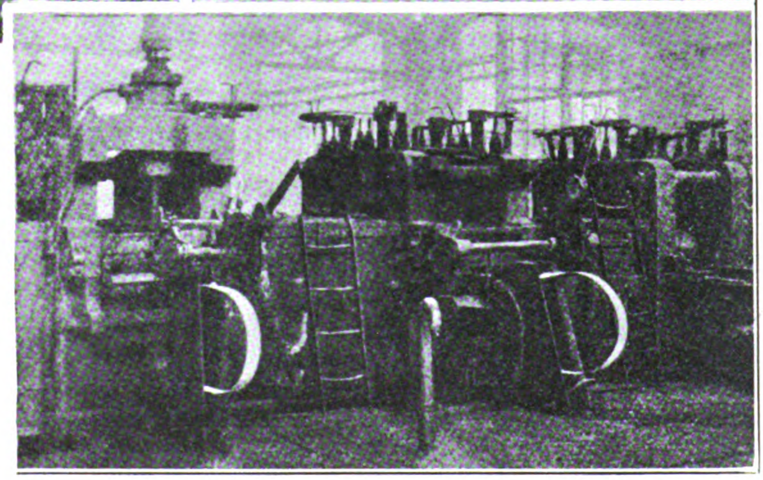


FIG. 10—Quast repeater.

wedge-shaped in the lower part and adhere closely to the facings. Their own weight holds them pressed firmly against the frame, thus ensuring an automatic and completely tight seal.

In order to side-discharge the sheet-bars, which are pushed through the furnace in an upright position, a mechanical pusher (Fig. 8) has been provided, which has proved satisfactory. It comprises two vertically arranged rollers, the top one being driven. The furnace man introduces a pushing rod between these rollers until it touches the sheet-bar to be discharged. By means of a foot-lever a compressed air cylinder is brought into play, which approaches the bottom roller to the driven roller, whereby the rod is pushed forward and the sheet-bar discharged out of the furnace.

Communication between the furnace and the first stand of the continuous rougher is established by an electrically operated, short roller run. The mill itself comprises a continuous rougher and an open finishing train.

Mill Lay Out

The rougher comprises four two-high stands of 360 mm (14.17-in.) straight in line. The stands are so far apart that the longest bands can issue freely, to be delivered to the next stand by means of a pinch roller device. The rougher is driven by an a.c. motor of 680/600 hp., 410/364 r.p.m. through bevel gears, with flywheel and spur wheels between. The pinch-roller units are driven by belts from the nearest housings.

Number of revolutions and rolling velocity of the four stands of the rougher are as follows:

	N.o.r.	Velocity
First stand	136/120	2.55/2.26 m/sec— 8.35/ 7.4 ft.
Second stand ..	170/151	3.20/2.82 m/sec—10.5 / 9.25 ft.
Third stand ...	215/190	4.05/3.57 m/sec—12.2 /11.7 ft.
Fourth stand ..	215/190	4.05/3.57 m/sec—12.2 /11.7 ft.

The first three housings have flat passes, the fourth is an edger.

Between the third flat pass and the edger the stock is turned upright and then delivered into the edger by means of vertical pinch rollers.

Since lack of space did not permit the installation of more than four two-high stands, the rolling pressure in them is comparatively high: in the first stand 20 to 25 per cent, in the second the maximum pressure of about 40 per cent, for which reason steel rolls are used, in the third stand again about 25 per cent.

The layout of the four housings of the roughing train was governed by the limited conditions of space. The original intention was to install five housings, the first to be an edger. This would have simplified storage conditions of the raw material, apart from allowing removal of scale in the first stand. To attain the latter, a blower has been placed before the first rougher stand, which comes into play with the passage of a sheet-bar, applying compressed air with addition of water. Besides a second scale braking application was installed behind the edger, operated hydraulically.

The finishing train comprises four double duo stands, with rolls 420 mm (16.53-in.) diameter and 600 mm (23.6-in.) length of body. The mill is driven by an A.E.G. regulation unit of 1400 kw. continuous output, through an enclosed three standard four pinion housing with flywheel and Orthmann coupling between. The regulation unit comprises an induction motor coupled to a d.c. compound motor, and a transformer on a separate base. This unit permits the variation of r.p.m. between 180 and 285 without waste, output remaining the same. At the smallest number of revolutions the rolling velocity is 3.95 m/sec. (12.87 ft.), at the highest 6.3 m/sec. (20.6 ft.).

The total number of passes in the finishing mill varies according to section. They roll: bands 50 to 70 mm wide (1.97 to 2.75-in.) in seven passes on the finishing mill with one Schoepf and two Quast repeaters, the crew consisting of three rollers and a boy; bands 71 to 130 mm wide (2.79 to 5.11-in.) in 5 passes on the finishing mill with one Schoepf repeater, and a crew of three rollers and a boy; bands 131 to 203 mm wide (5.16 to 7.99-in.) in 5 passes on the finishing mill, with no repeater, and a crew of 4 rollers, one helper and a boy.

The stock enters the first stand of the finishing train 11 mm (0.433-in.) thick. In case only 5 passes are required for the finished product, the stock receives flat passes only, but if seven passes are necessary an edging pass is added in the third stand.

Repeaters

From the first stand of the finishing train, which operates as upper duo, the stock is transferred laterally, by a Schoepf repeater (Fig. 9) to the lower duo of the second stand, which is a double duo. The Schoepf repeater has been improved upon by installation of a special covering.

A Quast repeater has been attached to the second and third stand of the finishing train, on the side facing the furnace, to transfer, in the second stand, from flat pass to flat pass, and in the third stand from flat pass to edging pass. This became possible by installation of a special twisting device.

Two compressed air operated scrapers are attached to the third and fourth stand, which are controlled by a boy from a raised pulpit.

The finished strip issues from the upper duo of the last stand over a channel trough onto the run-out trough, which is equipped with saw-toothed plates. Two electrically operated pinch-roller units are located in the run-out. The top-roll can be thrown out by compressed air motion, the bottom roll is driven. The pinch roller units deliver the strip to two electric reelers in the finishing department, where they are reeled into coils.

In order to deliver the outpouring band edge-up onto the floor plates, a turning and guiding device has been placed at the end of the run-out. This can be controlled from the operator's stand of the one reel and enables the delivery of the finished strip alternately to both reels. On issuing alternately the band is placed upright, at the same time going automatically into loops through friction on the floor plates.

If straight stock is to be produced, the top rollers of the pinch-roller units are disengaged and the bonds thrown onto a lateral run-out.

An electrically operated shear, which can be moved perpendicularly to the direction of rolling, is provided at the end of the cooling bed.

The production of the mill, allowing for shutdowns and changes, amounts to average 71 tons in a 10-hour shift, and it must be considered that 20 per cent of the production consists of steel and special steel. The maximum production so far amounted to 125 tons of good finished product in 10 hours, of strip 130 x 1¾ mm (5.12 x .069-in.). Power consumption 86 kwh. yearly average per ton of product, best figure 46 kwh.

The efficiency of the mill, working hours, shut-down hours, hours for building, operating time in hours, considering time required to change from one section to another, monthly capacity and production per hour of operation, also power consumed per ton in kwh. can be gathered from Table I.

Concluding it may be mentioned that the mill has fully answered expectations; it operates economically, producing good, clean stock of accurate dimensions and heavy coil weights.

TABLE I—Production Chart of the Strip Mill.

Month	Working hrs.	Shut downs	Building time	Time running	Mthly. prod.	Prod. in t/hrs.	Pwr. csd. kwh/t
February, 1927	319	15	39	265	2162.5	8.168	104
June, 1927	485	23	57	405	3669.9	9.056	88
Yearly average	337	22	65	349	3133.6	8.971	97
January, 1928	464	23	62	379	3584.6	9.463	93

Resume

Dimensions of various sections of strip, and of the raw material are given, the furnace with its charging and discharging equipment is described, the layout of the mill and its appurtenances to aid fast rolling are discussed, and data about production and power consumption are related.

Co-operation and Accident Prevention

The Story of a Successful Safety Campaign Staunchly Backed by the Officials and Based on the Full Co-operation of Each Individual Employee Is Here Recounted

By M. H. STEARNS*

JUST what can be accomplished in accident prevention when every man in the plant from the executive officers down to the most obscure workmen enters enthusiastically into a concerted effort to get results, is shown by the remarkable record established by the Donner Steel Company, Inc., Buffalo, N. Y., during the year 1924. This year is used for the reason that the compensation waiting period in New York State was changed beginning January 1, 1925 from 14 days to 7 days. To compare the 8 years prior to 1925 with the statistics from 1925 to date would therefore be unfair due to the amendment of the compensation law.

It was in the fall of 1917 that the writer became associated with the Donner Steel Company, Inc., and at that time their accident percentage was running too high. No systematic method of accident prevention had yet been established as it was only a short time prior to 1917 that the Donner Steel Company, Inc., came into existance. The World War was on and we all remember very well the great rush in every industry in the country—manufacturing any commodity that was needed by our Government and by the Government of our Foreign Allies. We had much to contend with, especially with the floating element who were jumping from one industry to the other in the rush for bigger wages and with the inexperienced worker who entered the steel industry for the first time.

Training the Individual

Much had to be done and the first step was to educate the workers both in how to work safely and in how to perform their duties. Therefore, safety committees, representing all nationalities were organized in every department in the plant. These committees included superintendents, foremen and workers. Not wishing to withhold any accident statistics from our employees, as was the practice prior to the enactment of the compensation law on July 1, 1914, every available fact concerning accidents and their causes was pointed out to our first safety committee. They were instructed to inspect their respective departments day and night and to immediately report to their foreman or to the safety department any unsafe conditions or practices that came to their attention. Of course, they were assured that the management in turn would back up their activities.

Interest was immediately aroused; they realized and appreciated the recognition given them by the management in appointing them safety committeemen. Suggestions began to pour in and, if found practicable, were complied with at once. In many instances the cost run into four figures. Accidents began to show a reduction and finally, we established in the year 1924 the remarkable record of 71.4 per cent reduction in accident frequency and 68 per cent reduction in compensation costs.

Every possible mechanical safety device was provided; meetings of the safety committees with their superintendents and a representative of the safety department were held weekly; departmental competition was created and prizes given for the best record with the result that every man was on his toes, eager to do his bit.

Rotation of Committee Membership

The safety committees are changed every three months, carrying over from the previous committee a few members as a nucleus around which the succeeding committee is built. The new committee begins to function at once, guided by the example set by the members of the previous committee. It is the duty of every committeeman to watch the new man and to immediately correct him if he observes that he is working unsafely. The new man, when employed is handed an employment card which is presented by him to his foreman or superintendent. If he happens to be a new man in the employ (not one re-hired) the words, "new man" is stamped on his employment card. This immediately calls to the foreman's attention the fact that he is a new man and he is then given verbal instructions in what his duties are and how to perform them safely so that neither he nor a fellow worker may be subject to injury.

---

*Safety engineer, Donner Steel Co., Inc., Buffalo, N. Y.

Up to the present time, due to the rotating of our safety committees, we have had nearly a thousand employees acting as safety committeemen. Our working force at the present time is about 2,000 men.

Banquets and Awards

Following the close of each year, all members of the safety committee who served during the year are tendered a banquet as guests of the Donner Steel Company, Inc. The entire management attends with the rank and file of the plant. Nationally known speakers address them on subjects of interest and monetary prizes are presented to a committeeman elected by the departments making the best accident reduction during the year. In addition to this, special bronze plaques are presented to each and every department who operate the entire year without a "lost time" accident. These plaques are 11¾ in. by 16¾ in. and become the personal property of the department winning it.

For the past few years our mechanical accidents have been practically eliminated. By this I mean accidents due to failure to provide proper guards, or faulty machinery. About 91 per cent of all our accidents are due to the handling of material.

Infections also are unknown here where the case is immediately reported. It is true that once in a great while a man will sustain a slight abrasion or laceration which he does not report and consequently a slight infection may develop. This is found in every industry, I believe.

At the present time we are competing with every similar industry in the State of New York in a statewide contest under the auspices of the Associated Industries of New York State, Inc. There are something like 1,200 industries entered in this contest and the winners receive special bronze plaques suitably inscribed, with the name of the industry winning it shown and these plaques are presented by the New York State industrial commissioner.

Thoroughly Backed by the Management

Earlier in this article I mentioned the fact that the management assured their entire backing to the safety movement and to bring this out more forcibly, I quote a letter written by our president following the establishing of our accident reduction record described before. The letter is as follows:

"The remarkable record which has been made by the men of Donner Steel Company, Inc., merely shows that where there is a will to accomplish accident prevention, actual results are bound to follow.

"This record is an example of what can be done when management and men work together in harmony with the assumption that most accidents are unnecessary and preventable. We could not have realized such improvement had not every man in our plant, from the executives down to the last man in the line, been sold on safety.

"While the company is saved compensation costs running into many thousands of dollars, a greater satisfaction lies in the humanitarian aspect, in the knowledge that serious injury to employees and fellow workmen is avoided and even lives are saved by this good work.

"I do not hesitate to give full credit where credit is due and that credit is due entirely to the stauch support given our safety department by every man in our organization."

(Signed) W. H. Donner, president.

The above letter tells the entire story in a few words.

Steels Used by the Automotive Industry

(Continued from page 1443)

part of this steel: In the automotive industry, this steel is used for wrist pins, ball bearing races and similar parts requiring an extremely hard case.

S. A. E. 4130 and S. A. E. 4140 steels have been adopted by some automobile manufacturers for axles, steering spindles, steering arms, bolts, etc. The chief difference in the application of these steels lies in the fact that 4130 is a water-hardening steel, while 4140 is an oil-hardening steel. These steels are considered commercially machinable at a hardness as high as 350 Brinell. Molybdenum confers on these steels the quality of forming a flaky, non-adherent scale, which is quite an advantage in some forging processes. The combination of high elastic limit and high ductility favored by the high drawing temperature of these steels is advantageous in the parts for which they are used, such as axles. Steel in an axle should have a high elastic limit but must also possess good ductility to prevent sudden failure should this elastic limit be exceeded. Steel containing molybdenum requires a considerably longer time at the drawing temperature than a steel of the same analysis without it.

Silico-Manganese Steel

In the American automotive industry, silico-manganese steel is a specialized purpose material, ordinarily being used only for springs. S. A. E. 9260 steel is the type generally used. A typical leaf spring treatment of this steel develops a tensile strength of 200,000 lbs. per sq. in. with a reduction of area of 20 per cent at a Brinell hardness of 415, which is an ample combination of physical properties for many automobile spring installations. This steel permits of a wider temperature range in forming and hardening operations than does carbon steel.

After considering the above you may well ask why some manufacturers use one steel for an axle, knuckle or some other stressed part, while other manufacturers use another grade. I may answer this by stating that this is a matter of individual opinion.

General Electric Sales Increase

General Electric Company sales billed for the first nine months of 1928, announced today by President Swope, amounted to $242,676,762.07, compared with $225,959,610.89 for the corresponding period last year. Profit available for dividends on common stock for the first nine months of 1928 was $38,841,625.31 compared with $35,193,054.70 for the same nine months last year.

The POWER PLANT

Practical Points on Feed Water Treatment

Various Methods of Treatment Are Reviewed Both with Regard to Results Attained and the Routine of Application—Operating Costs Discussed

By J. GUEST

JUST what constitutes satisfactory boiler feed water is a matter on which operators are rather in agreement. The requirements are usually set forth as follows: (1) Water should be free from scale forming solids. (2) It should be free from corrosive properties, either gaseous or otherwise. (3) It should be free from a high concentration of total solids likely to cause foaming and priming, or excessive blow-down.

The natural occurrence of a water answering these qualifications is extremely rare, and it is accordingly necessary to provide some means of treatment which will produce water conforming to these points. There are many various methods and arrangements to accomplish this, and all have merit in their particular field. In planning and selecting a water treating system, it is well to weigh all the surrounding conditions, and all the time spent in careful forethought will pay ample dividends. Too often is the matter of water treatment given only secondary consideration, and every effort is made to save pennies on the installation and operation, which in the end will cost the company dollars.

Methods of Treating Water

Perhaps the most common method of removing scale forming solids is through treatment with lime and soda. This treatment is used where the water contains sulphates together with sufficient bicarbonates to impair the action of the soda. It is in this classification that the greater part of supply waters fall. In this process, sufficient soda is used to break down the sulphates, and as much lime is added as is required to absorb the carbonic acid not taken up in the soda reaction. The reagents required per 1000 gals. for each grain of solid per gallon are as follows:

	Lime, lbs.	Soda, lbs.
Calcium carbonate	.117	....
Calcium sulphate	....	.112
Calcium chloride	....	.137
Magnesium carbonate	.28	....
Magnesium sulphate	.094	.126
Magnesium chloride	.124	.16
Sulphuric acid	.12	.156

An additional amount of soda should be added to hold the water on the alkaline side. From this table it is possible to calculate the amounts of lime and soda necessary to treat a given water. Barium chloride and sodium aluminate are also used to some extent.

Chemical treatment is applied in various ways. There are hot and cold processes, both continuous and intermittent in operation. In general it may be said that the hot process is more rapid, heat speeding up the chemical reactions involved in the softening. This means smaller tanks than are necessary with cold processes, inasmuch as less storage capacity is required to allow complete chemical reaction.

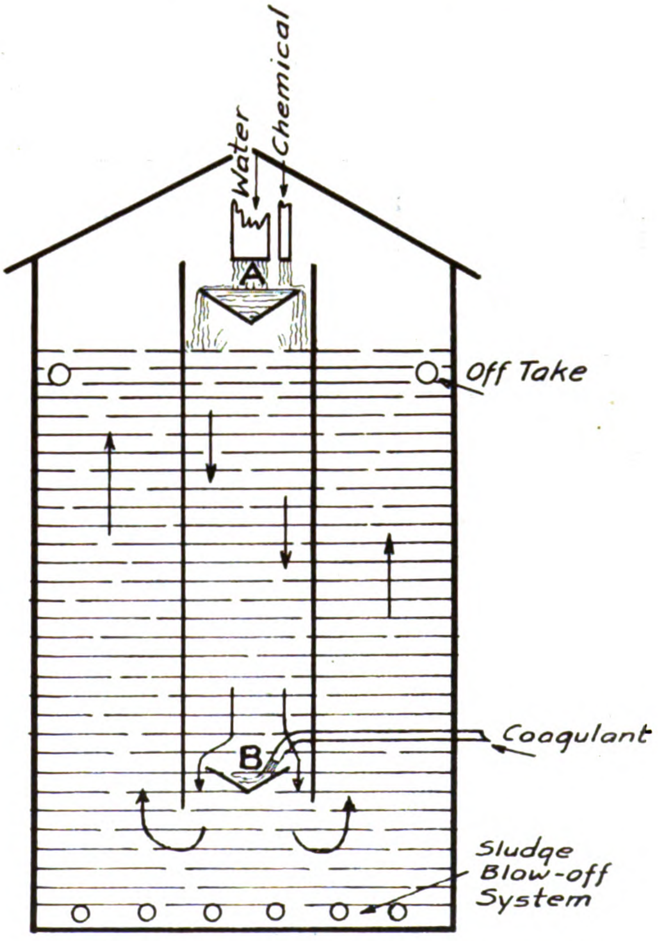


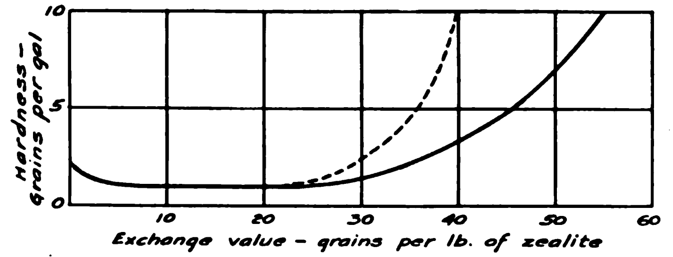
FIG. 1—Arrangement of sedimentation tank in continuous process.

In the cold intermittent process, a tank is filled with water, and the required amount of chemicals added. This is agitated and then allowed to settle, the insoluble salts resulting from the treatment precipitating out. This requires a certain amount of time and under no conditions should the capacity of a softener be pushed so that less than four hours are given for treating and settling a tank of water.

In any continuous process, the chemicals are constantly added to the water in proportion to the rate of flow. This is usually accomplished by making use of the differential pressure set up by the flow of water through an orifice or venturi tube, or of the principle of proportional flow through orifices of different size under equal pressure heads. These primary actuating elements are then transferred to proportioners of widely varying designs, which control the flow of the chemical solutions. A discussion of this equipment lies outside the scope of this article and the reader is referred to the catalogs of the various manufacturers for detailed information.

Design of Tanks

In the cold continuous process, the sedimentation tank should be large enough to hold four hours supply at the maximum rating of the plant, so as to allow sufficient time for complete reaction and settling. The usual design of these tanks is shown in Fig. 1. Chemicals are mixed with the water at A, move through the down-comer, then up around the outside of the down-comer. The tank and down-comer should be so proportioned that this upward velocity does not exceed .3 ft. per min. in order to allow the solids to settle down. If no coagulant is used, this down-comer is often of the stub type, located at the bottom of the tank. When a coagulant is used, however, it is added to the water at B, Fig. 1, and the down-comer should then be proportional so that approximately one-half hour will elapse between the addition of the softening chemicals and of the coagulant.



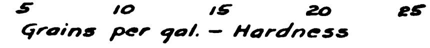


FIG. 2 (upper)—Results of hardness tests on zeolite treated water. Dotted line shows a zeolite which has been badly overworked.

FIG. 3 (lower)—Salt required by zeolite softeners.

The use of coagulants is not necessary with all waters, their need being determined by the clarity of the treated water. The materials usually used are ferrous sulphate and aluminum sulphate. If ferrous sulphate is used, it is necessary to increase the amounts of lime and soda used by .4 lbs. of soda and .22 lbs. of lime for each lb. of iron sulphate used. Alum requires somewhat less softening reagent to counteract its effects.

In general, less trouble is experienced handling the chemical solutions with centrifugal pumps than when reciprocating pumps are used. Pumps for alum should be of acid resisting metal. All pipes or cables in solution tanks should be of bronze. Chemical lines can be cleaned by circulating muriatic acid through them.

Mention should be made of various internal treatments, wherein the softening reagent is introduced directly into the boiler. Due to the fact that this method introduces additional solids into the feed water, its use is rather limited in the boiler field.

Removal of Precipitators

After any of these external methods of treatment, it is usually necessary to filter the water, accomplished by passing the water through a sand bed, suitably sized and graded, which strains out and holds the suspended solids. When the solids build up to such an extent that the pressure drop through the filter bed is excessive, the filter bed is backwashed, using a flow of 12 to 15 gals. per min. per sq.ft. of filtering bed surface. It is sometimes desirable to supplement the back washing with compressed air agitation, particularly if the fore-mentioned rate of water flow is not available. It is well to select filters with a liberal capacity, using a filtering rate of 2 to 4 gal. per min. per sq. ft. depending on the amount of sediment in the water.

Filters may be either of the pressure type or of the gravity type. In the former the filter bed is in a closed tank, subjected to the working pressure of the water, while the latter makes use of open containers. Either type is satisfactory and the selection between the two types should be governed by local conditions.

The strainer system, consisting of pipe manifolds and laterals carrying the strainer heads, is usually concreted in the bottom of the filter. These strainer heads are of various designs, in the attempt to prevent clogging, and should be made of bronze to resist corrosion. To eliminate the trouble usually experienced with strain systems, a conical filter has been designed which replaces the strainers with an inverted cone uptake for taking off the filtered water. Strainer heads are often cleaned out by washing in muriatic acid. Concrete mixers are often employed to wash the sand and gravel of the filter bed when occasion demands.

Zeolites

Perhaps the simplest of all forms of treatment is the zeolite softener, and it has come into great usage in the past few years. Zeolite is a bi-metal silicate. which absorbs the calcium and magnesium in the water, converting these salts into the soluble sodium salts. By a regenerative process with common salt, the sodium is replaced in the zeolite, and it is again in shape to soften water. It is to be noted that nothing is removed from the water, but that the salts present in the water are merely converted into the soluble salts. Hence, very hard waters so treated will give high concentrations in the softened water. Just where the limit of this treatment lies is subject to varying conditions, but it seems to be a general opinion that for feed water to boilers operating at high ratings, this method should not be used on waters running over 15 grains hardness per gal. If this limit is exceeded, excessive blow-down is required to prevent the boilers from priming and foaming. Also, the theory is advanced that the ratio of sodium sulphate to sodium carbonate in the treated water for boiler feed purposes should be at least equal to 2 in order to prevent possible promotion of caustic embrittlement.

Zeolites have exchange values running from 30 grains per lb. of sand for the natural green sand, up to as high as 10,000 grains per lb. for the synthetic manufactured zeolites. Though requiring larger equipment for the same capacity, the natural sand seems to be preferred, particularly for industrial plants. Filtration rates for zeolite softeners should run 3 to 4 gals. per min. per sq. ft. Backwash should be at a rate of 6 to 8 gals. per min. per sq. ft.

Suspended matter in the water will coat the zeolite grains, reducing their efficiency. Acidity, free CO_2, or hot water are also harmful. Over-running the zeolite, that is, working it beyond its normal exchange value, is apt to break down its efficiency as shown by the curve in Fig. 2.

The amount of salt required in this process depends on the hardness of the water. The curves in Fig. 3 show the amounts required for waters of varying hardness. Only a definite quantity of sodium is replaceable, and salt in excess of the amount shown will have no effect and will only be wasted. The practical amount to be used is somewhat higher than the theoretical amount, due to loss of salt in the process of regeneration. This loss depends on the efficiency of the regenerating equipment. The amounts of salt shown in the curve may vary slightly according to the exchange value at which the sand is worked, but in general, 1 lb. of salt is required for every 2,000 grains of hardness exchanged.

Combined Methods

Where the characteristics of the water supply demand, various combinations of methods of treating have been employed. For example, before going through zeolite softeners, turbid waters are treated with a coagulant and then filtered; extremely alkaline or hard waters receive a pre-treatment with chemicals; where evaporators are used, the water is often given some softening treatment to eliminate scale in the evaporators.

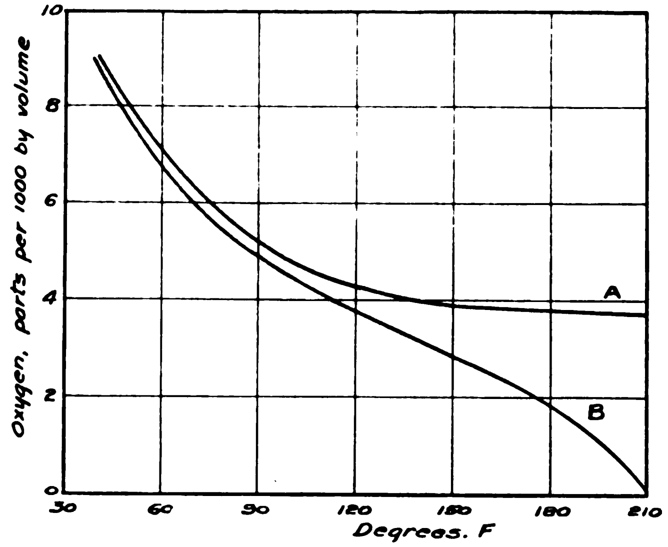
A typical example of a combination treatment is that employed in an industrial plant. Water is taken from wells, and is exceedingly hard. A cold continuous process partially treats the water with lime, removing the carbonates. Aluminum sulphate is used as a coagulant. The water is then put through pressure filters into a clear well. From here, the water required for boiler feed purposes is put through a zeolite softener. This amounts to 20 to 25 per cent of the total water treated. The balance of the water is used as make-up for a spray pond serving surface condensers. This water is given an acid treatment with a solution of niter-cake in order to prevent any further precipitation in the cooling system. This plant has been operating for about two years with excellent results. Operating averages show that the chemicals used run as follows:

Lime	1.63	lbs. per 1000 gal.
Alum	.343	lbs. per 1000 gal.
Niter cake....	.81	lbs. per 1000 gal.
Salt	4.9	lbs. per 1000 gal. of zeolite treated water

A typical month's production is 24,000,000 gals. total, at an average cost of 5 cents per 1000 gals. over and above the cost of raw water. Water analyses from various stages of this treatment are given in Table I.

Effect of Dissolved Gases

All waters usually carry a certain amount of dissolved gases. When this water is treated so as to remove all incrusting solids, these gases come into direct contact with the boiler tubes and shells, causing pitting or corrosion. This is particularly noted when zeolite softeners are used, as there is no deposit whatever left to protect the tubes from the action of the dissolved gases. It is often found that, while the original water supply is almost free from gases, a considerable amount of oxygen is picked up in the treating and filtering plant. In one case of this kind, the raw water supply showed only .056 parts per 1000 of oxygen, while the water leaving the treating plant showed 5.712 parts per 1000.



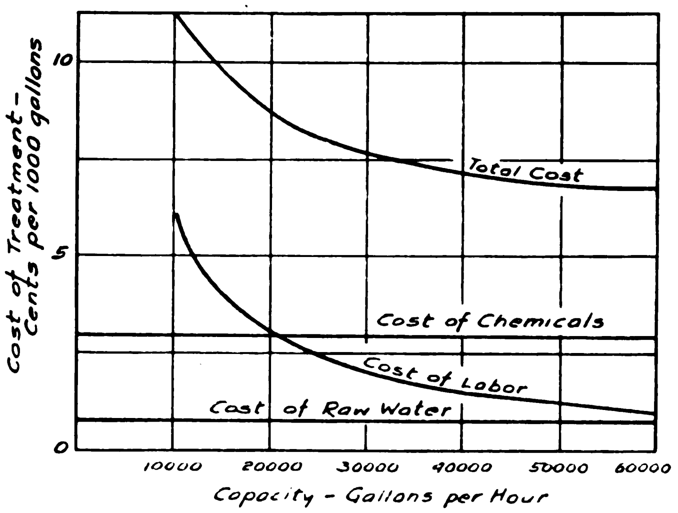
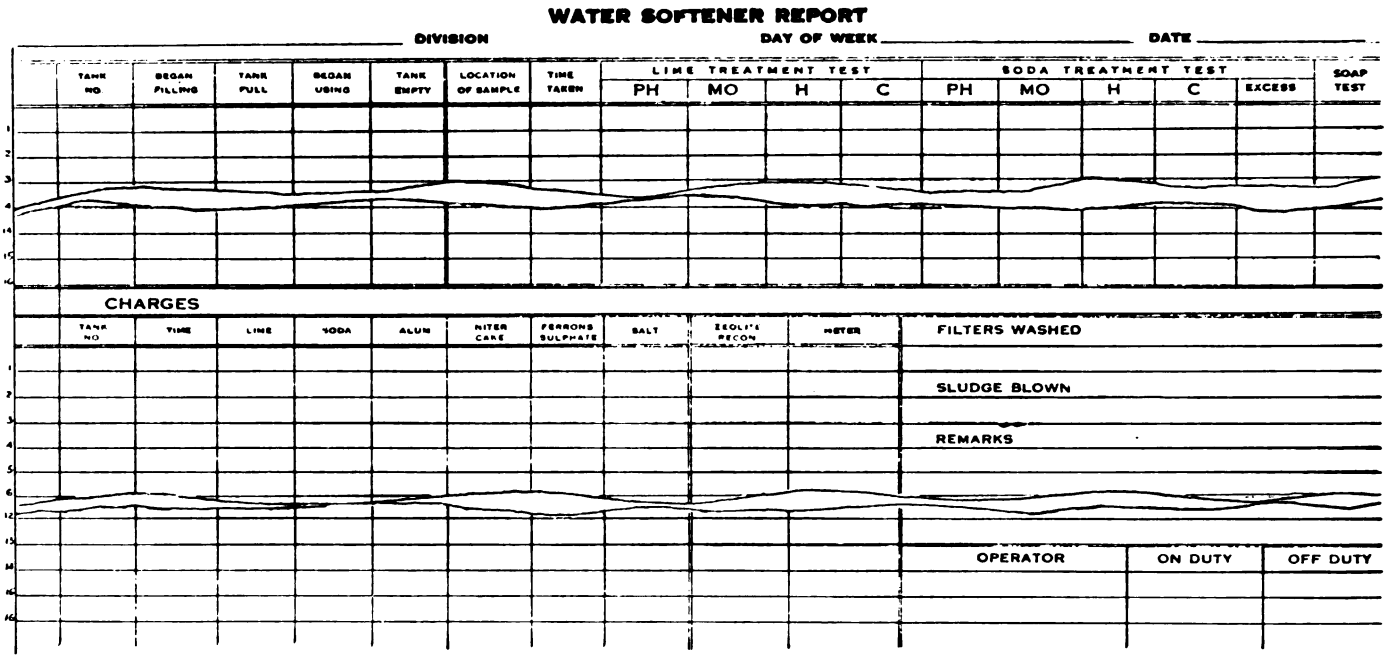


FIG. 4 (upper)—Solubility of air in water.
FIG. 5 (lower)—Variation in operating costs for treating plants of various sizes.

It is, therefore, necessary to remove these gases in order to insure the boilers against corrosion, and also to insure good condenser performance. This process of deaeration is based on the following principles:

1—Reduction of solubility of dissolved gases in water with increase of temperature.



WATER SOFTENER REPORT

DIVISION ______ DAY OF WEEK ______ DATE ______

	TANK NO	BEGAN FILLING	TANK FULL	BEGAN USING	TANK EMPTY	LOCATION OF SAMPLE	TIME TAKEN	LIME TREATMENT TEST				SODA TREATMENT TEST					SOAP TEST
								PH	MO	H	C	PH	MO	H	C	EXCESS	
1																	
2																	
3																	
4																	
14																	
15																	
16																	

CHARGES

	TANK NO	TIME	LIME	SODA	ALUM	NITER CAKE	FERRONS SULPHATE	SALT	ZEOLITE RECON	METER
1										
2										
3										
4										
5										
6										
12										
13										
14										
15										
16										

FILTERS WASHED

SLUDGE BLOWN

REMARKS

OPERATOR	ON DUTY	OFF DUTY

FIG. 6

2—Explosive boiling caused by rapid injection of heated water into a zone of lower boiling temperature.

3—Control and agitation of water subsequent to explosive boiling in regions of reduced air tension.

The open feed-water heater removes some oxygen due to the first principle stated above. Deaerators are of various design, usually based on a combination of the above principles. It is not possible to thoroughly deaerate water in an ordinary atmospheric heater. Gases dissolve in any selected solvent in the direct ratio of their pressures. The solubility of air in water with varying air tension is as follows:

Air tension, ins. mercury	Air solubility, cc. per liter
.2	.026
.4	.052
.6	.079
.8	.105
1.0	.131
1.2	.158

A steam jet ejector is usually employed to produce a vacuum in the shell of the deaerating heater. The reduction of air tension is secured partly by the reduction of the total pressure, incident to the vacuum, and with proper control of the boiling point, partly by a partial vapor component of the total pressure which reduces the partial air tension. The sum of this partial air tension and partial vapor component is equal to the pressure in the region of the vacuum. Fig. 4 gives curves showing the extent of oxygen removal under different conditions of air tension. Curve A is with a total air pressure of 29.92 in. hg., while curve B is with the sum of the partial air pressure and the pressure of the water vapor equal to 29.92 in. hg. The performance of an atmospheric open heater will fall between the two curves. If this total pressure of 29.92 in. hg. were to be reduced by means of some form of vacuum pump, oxygen removal would be more complete.

A check on a typical commercial deaerator, wherein a partial vacuum is maintained by means of a steam jet ejector, gave results as follows:

Temperature of water entering the deaerator, deg. F.	165.2
Steam temperature in deaerator tubes, deg. F.	299.
Temperature in shell of deaerator, deg. F.	207.5
Temperature of water out of deaerator, deg. F.	207.4
Steam pressure to deaerator, in. hg.	9.23
Vacuum in deaerator shell, in. hg.	1.635
Water flow, lbs. per hour	238,000
Average oxygen content, cc. per liter	.019

This test covered a period of 8 hours. A peak water flow of 420,000 lbs. per hour was reached. Oxygen contents varied between limits of 0 and .05 cc. per liter.

If oxygen content of boiler feed water is kept at .05 cc. per liter or less, no trouble is usually experienced with pitting or corrosion from this source.

Operating Costs

The costs of operating a treating plant will vary considerably with the amount of labor required, the characteristics of the water to be softened, and the size of the plant. The curves in Fig. 5 show variation in costs for plants of various capacities. These curves in question are based on lime and soda ash process, with labor at 60 cents per hour, and water of about 20 grains hardness. This variation is similar for any type of plant. The chemical cost is a straight line, barring the possibility of obtaining lower prices due to buying in large quantities. Labor cost is based on the services of one man during the entire 24 hours of the day. In some cases, constant attention is not necessary, in which the man's time can be split with something else, and the labor cost reduced. In some plants, softeners have been installed in the boiler house, requiring no additional labor over that required for boiler room operation.

Regardless of the type of softening plant installed, a constant check should be kept on the treated water. These tests require very little time, and afford a means of detecting irregular operations before any great damage is done. It is well to have these titrations performed by someone other than the operator of the plant. The method of performing these tests are so well known as to require no discussion here. The results of the tests should be kept on a log sheet, of which one form is shown in Fig. 6. This was made up so as to be applicable to both intermittent and continuous plants, employing various chemical treatments, as well as zeolite. It gives a complete record of the amount of water softened, the amount of chemicals used, the time allowed for treating, the results of the titrations, as well as any adjustment or repairs made on the equipment. Individual forms can be made up to suit each plant, and when properly made out, afford an excellent guide to the man in charge of the plant.

Also, regular periodic inspections of the softening equipment should be made. This will often forestall accidents which would otherwise upset the routine of treating. When the proper method and routine for treating has been set up, it should be closely adhered to. Seemingly small changes may produce very bad results. For a given installation, reactions cannot be hurried beyond a certain point without getting into trouble. The whole matter requires careful study and then careful operation. The saying "Treat your water right and it will treat you right" is well worth remembering.

TABLE I—(In parts per 1,000,000)

	Raw well water	Lime and alum*	After niter cake	After zeolite
Total hardness, .as $CaCO_3$	350	164	164	...
Calcium hardness ....as $CaCO_3$	225	100	100	...
Magnesium hardness ....as $CaCO_3$	125	64	64	...
Alkalinity, M.O..as $CaCO_3$	241	45	15	45
Basicity—Alkalinity, Ph..as $CaCO_3$	...	6	...	6
Free carbon dioxide ....as CO_2	44	...	1	...
Chlorides ....as Cl	85	86	86	86
Sulphates ......as SO_3	113	140	164	140
Iron ....as Fe	.4	...	...	...

*Treated, settled and filtered.

Water Lubricated Bearings Used on Large Pump Installation

The largest pump that has ever been constructed by The Pomona Pump Company of Pomona, Calif., has just been installed and is in operation for the Etiwanda Water Company, Calif.

This pump breaks all records in size and lift and its operation is attracting wide-spread attention, not only among hydraulic engineers, but in electrical circles as well. The weight of the pump is 60,000 lb. It is installed in a well of 450 ft. depth and not only raises the water from this depth but boosts it an additional 190 ft., making a total head of 640 ft. The water is boosted to a hill where it is redistributed to lines and laterals for use in irrigating.

Etiwanda is located in the heart of the deep well district where many Pomona pumps are operating at depths of 300 ft. to 400 ft. and several at 550 ft. The lifting and boosting of the water is accomplished in one operation and a most novel feature of the design is the fact that the bearings are water lubricated. In the usual oil lubricated bearing some trouble is experienced in clogged oil lines, which may cause oil failure and bearing trouble, and for this reason this Pomona pump has been constructed to use the ever present water as a lubricant. Water with sand intrusion causes rapid cuttings of the bearings but in the Pomona pump design these bearings are of a unique type that cannot be rapidly destroyed by sand. Furthermore any sand that creeps into the bearings is washed out without permitting metal-to-metal contact that causes abrasion.

This is the largest pump that has ever been installed with the special water lubricated bearings and it proves conclusively that water lubrication is just as satisfactory for large capacity pumps as for the smaller 6-in. pumps.

All of the parts for this huge pump, which is said to be the highest pressure turbine pump ever built, were constructed in the factory of the Pomona Pump Company with the exception of the motor which is a Westinghouse 350-hp., 50 cycle, 960 r.p.m., ball bearing, vertical solid shaft design. This type of motor has proved exceptionally satisfactory, according to W. H. Day, vice president in charge of sales, especially in the agricultural districts where temperatures are extremely high. Many Pomona pumps are in operation in Coachella Valley and at other desert locations where temperatures frequently reach 115 deg., requiring a motor that has high ventilating efficiency.

Seventh National Power Show

A feature of the Seventh National Exposition of Power and Mechanical Engineering this year will be a motion picture program running through the entire week of the show from December 3-8 inclusive.

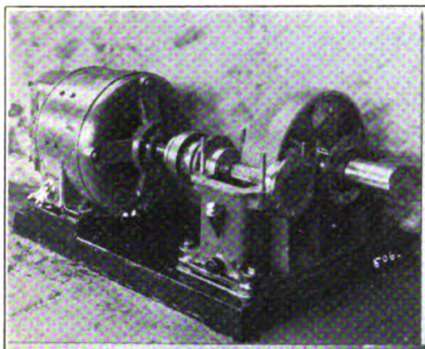
The films cover a wide field and run from one to five reels. Some of them are to be shown for the first time, the date and time of the showing to be announced later.

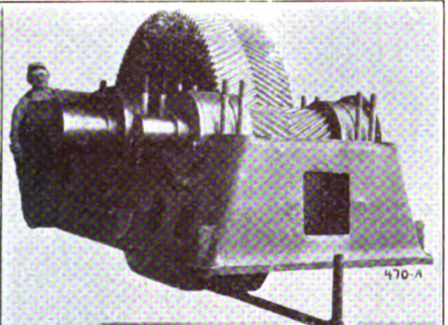
WITH THE EQUIPMENT MANUFACTURERS

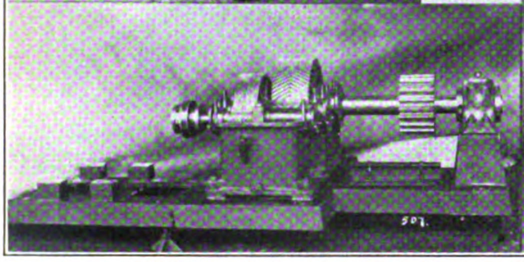
Speed Reducers

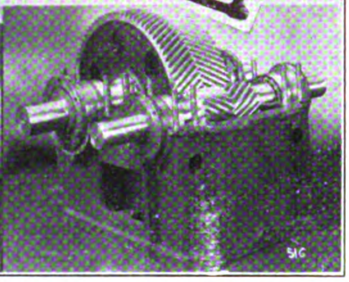
The Farrel-Birmingham Company, of Buffalo, N. Y., announce a new and complete series of speed reducers which have Sykes continuous tooth herringbone gears and anti-friction bearings. The improvements claimed for this new design of reducer are:

1—The roller bearings being of the type which combine journal and thrust capacity, both pinion and gear shafts are held from end float and are therefore protected from abuse from connected mechanism. The Farrel-Birmingham Company claim that this type of mounting is practicable with the Sykes gear since the apices of the teeth are central in the face of the gears around their entire periphery, and no end float of either gear or pinion is necessary.









2—The mechanical efficiency is increased to between 98½ to 99 per cent for a single reduction and from 98 to 98½ per cent for a double reduction.

3—The lubrication is simpler than with the plain bearing units since in all cases the same oil may be used for gears and bearings and the splash and flood automatic system of lubrication is possible throughout the whole series.

4—There is a considerable saving in space.

5—The roller bearings being interchangeable, it is possible to make the gear units interchangeable and to manufacture them in larger quantities than the plain bearing type units, thereby reducing the initial cost.

Illustration 506 shows a single reduction unit mounted on a common baseplate with motor. This series is suitable for ratios between 2:1 and 10:1, and powers between 3 hp. and 300 hp.

Illustration 507 shows a double reduction unit suitable for ratios between 10:1 and 60:1, and powers between 5 hp. and 200 hp. This illustration also shows a typical outboard mounting where generated straight tooth gears are used for the final reduction.

Illustration 516 shows a heavy duty type unit which has a strong box section, pedestal supports for the bearings, and is suitable for ratios from 1:1 to 10:1 and powers between 100 hp. and 400 hp.

Illustration 470-A shows a rolling mill type unit which is suitable for powers between 300 hp. and 500 hp. The bearings are held in sleeves to facilitate adjustment and allow for shaft expansion. The case is of box section girder design extending from the center line of the shafts to the base, and it represents the most modern practice in rolling mill drive design.

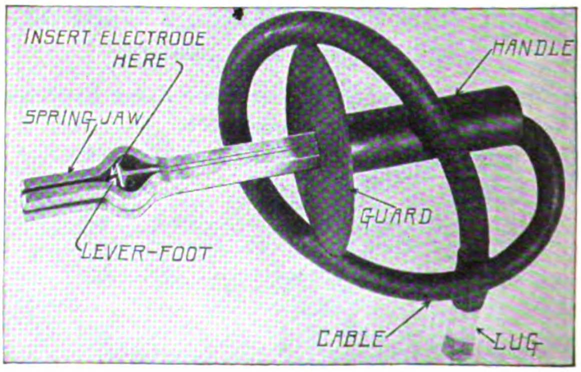
The Farrel-Birmingham Company have just published a new booklet describing this series of units and giving charts containing horsepower capacities, general data on Sykes gears and illustrations showing their application.

New Welding Equipment

The Fusion Welding Corporation, 103rd Street and Torrence Avenue, Chicago, Ill., has recently brought out a new electrode holder for metallic arc welding which has several unique points of advantage. It is claimed by the makers of this electrode holder that the principle cause of electrode overheating is improper contact in the electrode holder.

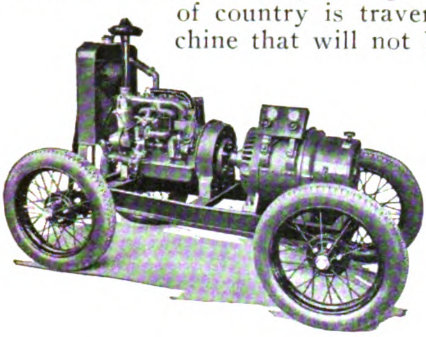
The act of inserting the electrode in this new Fuzon Model A holder automatically scrapes off any insulating material that may be present on the welding rod insuring four clean points of firm contact and thereby minimizing the overheating of the electrode.

In addition, attention is called to the simple construction of this holder which has no springs or moving parts. The jaws are made of the same special copper alloy that is used to support and attach trolley wires to the cross wires. This alloy resists arcing, and as this arcing in the holder jaws is the principal cause of damage to most holders it is felt that the Fuzon holder will last longer.



Spattered drops of electrode metal will not stick to this copper alloy and the holder stays clean. It is very easy to load and when the electrode has been inserted between the jaws it may be placed at any desired angle to facilitate work in difficult welding positions. The act of inserting a fresh electrode automatically ejects the stub end of the old electrode without the welder touching it. The holder is very light in weight considering its unusually substantial construction and is nicely balanced so as not to fatigue the welding operator.

The Fusion Welding Corporation has also brought out a portable welder. Wherever a car can be driven this welder can be taken. The front wheels, being jointed to the handle, turn as the handle turns. The center of gravity is low. It will not overturn when taken across rough ground. For pipe line welding when the welder must go along no matter what kind of country is traversed, here is a machine that will not be left behind. For repair jobs in the far end of the big plant, the inaccessible place, here is a welder that will go there and furnish its own power after it gets there.



Many uses can be found for this new gas engine driven arc welder that is portable in fact as well as in name. But its portability is only one and probably not the most important feature of this new Fuzon welder. Fully as important to the man who uses this machine is the "peppy," easily controlled welding arc that he finds the moment he touches the electrode to the work. There is no "vanishing" of the arc no matter how hard it is pushed. Quick changes in arc length do not discourage this welding arc. It instantly accomodates itself and the metal keeps on depositing. A patented method of interpole connections in the generator puts an inherently stabilized current into the welding line and gives the Fuzon welder its unsual arc action. The single brush shifting control calibrated in amperes give an infinite number of possible current settings with arc characteristics just as favorable at the lowest as at the highest settings.

Continental motors of ample power—23 hp. for the 200-ampere and 40 hp. for the 300-ampere set—guarantee a dependable power supply. An automatic governor keeps the motor speed constant.

Prest-O-Lite Flood Light Attachment

The Prest-O-Lite Company, Inc., 30 E. Forty-second Street, New York City, announces a flood light attachment of new design for use with the familiar small tanks of dissolved acetylene, the same as are used for truck and tractor lighting.

Prest-O-Lite gas tanks are available from service stations throughout the country. By the connection of the attachment a convenient, portable, powerful flood lighting unit is obtained which can be used for illumination in dark places and for facilitating night work of all kinds.

The improved attachment, illustrated, is of simple, strong, rigid and compact construction. Universal adjustment is obtained with only one swing joint, this minimizing the possibility of leakage.

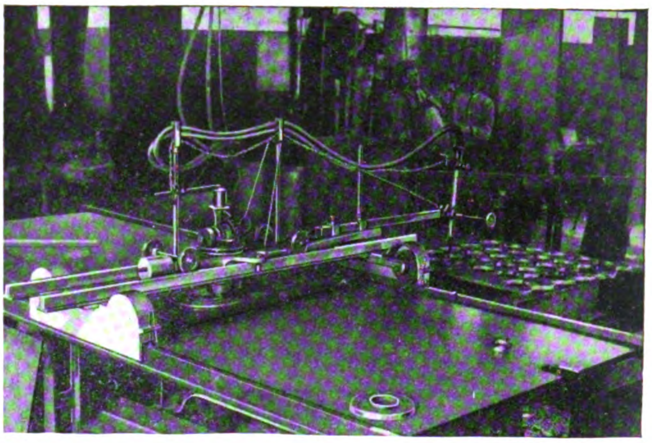
Because of the substantial construction of the new part and because of its position near the center line of the tank, the attachment itself can be used as a handle in carrying the entire unit.

The reflector, which is 10 in. in diameter can be taken off by removing a single knurled nut. A new type of burner is used which will not "carbon up." This burner is placed at a fixed focal point and requires no adjustment.

The Oxweld Shape Cutting Machine

An automatic oxy-acetylene shape-cutting machine designed to cut shapes of any sort from steel plate, sheet, forgings, billets or ingots is being introduced by The Linde Air Products Company, 30 E. Forty-second Street, New York. In this machine the cutting blowpipe is mounted on a carriage which is moved in any direction by means of an electric motor. For routine production it will operate automatically from templets. In cases where only a few parts are to be cut out a hand tracing device can be attached and used to follow the outline of a sketch or blueprint.

The Oxweld shape-cutting machine requires but one operator. Little machining is necessary in most cases after cutting because the parts are produced with straight corners and smooth faces. The speed of cutting is very high and ranges from 3 to 20 in. per minute, depending on the thickness of the metal. Accurate and smooth cuts can be made in stock up to 1 ft. and more in thickness. Production costs are reduced sharply owing to economies in labor, time and material.

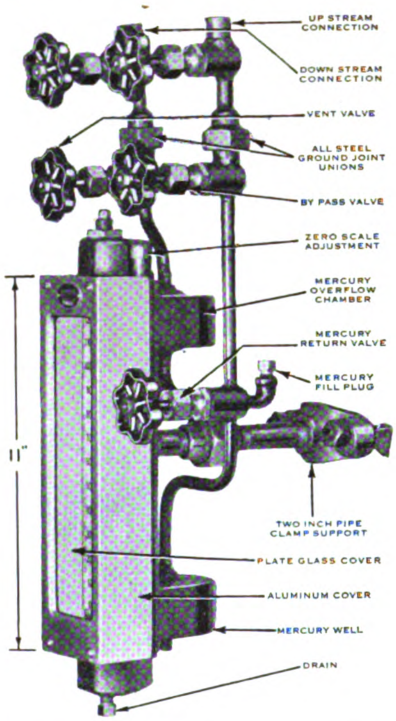


Indicating Flow Meter Welded by Atomic Hydrogen Process

The Meriam Company, Cleveland, Ohio, have now placed on the market a new type of indicating flow meter suitable for measuring the flow of air, gas, saturated or superheated steam, oils and other liquids at any temperature, vacuum or pressure.

Primarily the meters are designed for high line pressures—1000 lbs. per sq. in. or even higher, but with slight modifications they may be used with equally satisfactory results on vacuum or on low pressures. Their operation depends upon the fact that the flow of the liquid or gas causes a loss of pressure along the pipe. To insure correct readings, an accurately-proportioned orifice-disc is placed in the path of the flow in the pipe, and two small tubes are connected to the pipe line, one on each side of the orifice disc. The difference in pressure between the two sides is recorded by the level of mercury, or other non-evaporating liquid of constant weight. Since there are no gears, springs, etc., it is evident that the meter gives unusually accurate results over long periods. The orifice-disc, being made of monel metal, will not wear or corrode. It is obvious that the scale may be calibrated in cubic feet, barrels, pounds, gallons, or other quantities per hour if desired.

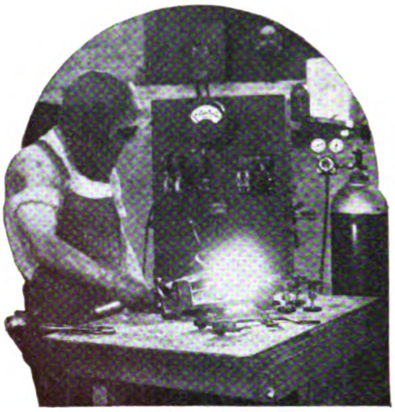
The construction of these meters presented some interesting features. In view of the very high pressures which must be dealt with in many cases, and to the inaccuracy which would be caused in the readings by even the smallest leakage under circumstances, it was decided to weld all pipe-lines, valves, etc., in the meter connections instead of using threaded unions. After considerable experimenting with various types of welding, the new atomic hydrogen welding was used; and this method, it is stated, not only makes a perfectly solid and non-porous weld but also requires no extra grinding or finishing to give a clean finish.



The atomic welding method combines the advantages of both the gas and arc welding systems, but the heat—and consequently the speed and ease of operation—is considerably in excess of either of the other systems.

The welding "torch" consists of a pair of adjustable tungsten electrodes between which the electric arc is maintained, and a tube and valve communicating with a cylinder of compressed hydrogen. The hydrogen is directed over the electrodes on to the work, thus covering the molten area of the work with an envelope of non-oxidizing gas and avoiding the usual "scaling" which takes place when metals are highly heated. This assures homogeneous welds.

Another important advantage of the atomic welding process is the very high heat produced. The hydrogen is split up into atoms and the energy thus freed creates a temperature which is stated to be as high as 8000 deg. F.—the highest heat ever produced by artificial means.

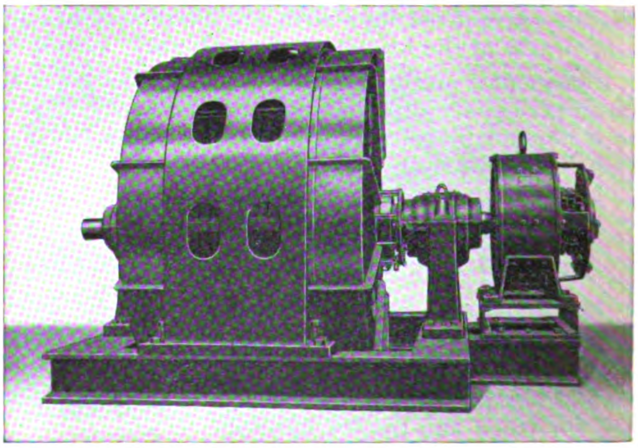


The welding plant used by the Meriam Company for the construction of these flow meters is stated to be one of the first of its kind ever installed in Cleveland.

Fabricated Frames on Enclosed Synchronous Condensers

The Westinghouse Electric & Mfg. Company has recently issued leaflet 20369, a publication on enclosed synchronous condensers.

There are two types of these machines—semi- and totally enclosed. Both types have electrically welded plate steel frames. In the semi-enclosed type the cooling air is drawn in along the shaft and forced through the machine by fans on the rotor. The warm air is discharged around the periphery. In the totally enclosed type the air is drawn through the outer end bells at the bottom of the machine and is discharged at the top.



All condensers have laminated type rotors with dove-tailed poles and are provided with damper windings so as to make them self starting.

Digitized by Google Original from UNIVERSITY OF MICHIGAN

TRADE PUBLICATIONS

The Cleveland Crane & Engineering Company, Cleveland electric tramrail division, Wickliffe, Ohio, is distributing the new Cleveland tramrail catalog, No. 4, an attractively bound series of bulletins, indexed and very completely illustrated. The book represents a comprehensive study of the fundamental principles of material handling as applied to the important manufacturing industries and will consequently be found a valuable handbook in that connection. Special attention is called to Bulletins 1001-2-3-4 which describe the Cleveland tramrail rail.

* * *

"Preparation of Slag for the Market," is the title given to Symposium No. 6 compiled by the National Slag Association, 937 Leader Building, Cleveland, Ohio, and issued in pamphlet form. Engineers desiring to secure information on the various methods of preparing and handling slag from the molten state until it is placed in the car for disposal, will find this pamphlet quite instructive.

* * *

The Chicago Pneumatic Tool Company, 6 East Forty-fourth Street, New York City, is releasing the following bulletins: No. 700 (third edition) describes in detail power driven duplex air compressors and illustrates the points of construction that occur on operation and maintenance. No. 720 (fifth edition) covers in a similar manner straight line air and gas compressors, steam and power driven. No. 733 (second edition) makes clear the features of the "Giant" semi-Diesel oil engines class A-O4. No. 786 (first edition) describes vertical duplex compressors, type P-6, and No. 787 (first edition) portable compressors electric driven. Bulletin 788 (first edition) covers the vertical "Simplex" power driven compressors.

* * *

"The Green List," a catalog of currently available re-manufactured machine tools, for Autumn 1928 is being distributed by Hill Clarke & Company, 649 W. Washington Boulevard, Chicago. The machines listed are described and many of them are shown in illustration.

* * *

Bulletins from the General Electric Company have been received as follows: G.E. A-71-B wound-rotor induction motors, "900 series," Type MT (3-phase) and Type MQ (2-phase) various voltages and from ¾ to 10 hp. G. E. A-81-B high-torque double squirrel-cage motors "900 series" frames, Type F.T.R. (3-phase) and Type F.Q.R. (2-phase) constant speed, 3 to 15 hp., larger sizes available. G. E. A-821-A, C. R. 2927 pressure and vacuum switches for motor driven pumps or compressors for maintaining a predetermined pressure or vacuum.

* * *

Among recent publications of the Westinghouse Electric & Mfg. Company is leaflet 20383, descriptive of the adjustable insert, designed to facilitate mounting machinery or other equipment to floors, walls or ceilings of concrete. The insert has a cast iron housing which may be set in concrete. A rotatable bolt carrier of high grade malleable iron, T-slotted to take the head of a standard square head machine bolt is held in the housing by a retaining spring and steel plug pressed in at the back. The housing and bolt carrier both are provided with teeth which mesh and prevent any change in position after the adjustment has been made and before the bolt is tightened. The inserts are available for use with ⅜ and ½ in. machine bolts.

* * *

Farrel-Sykes roller bearing type speed reducers from 1 to 5,000 hp. are described and illustrated in a 24-page pamphlet now being distributed by the Farrel-Birmingham Company, Inc., Buffalo, N. Y. Gear data is included as well as an illustrated description of the Sykes gear generators.

* * *

LaClede Christy Clay Products Company, of St. Louis features "laboratory tested" fire brick in a 4-page folder. The testing methods are shown in illustrations, and the point stressed in the text of the folder is the application of the proper kind of fire brick for each definite requirement of service.

* * *

"How the Other Fellow Does It," from Brown Instrument Company, the second folder of a series illustrating modern heat treating problems and appliances, features 22 jobs using gas-fired furnaces and temperature controls. Illustrations show the equipment for each class of work described.

* * *

The Norton Company, of Worcester, Mass., is distributing three recent booklets. One is concerning saw sharpening in the Southern saw mills and one describes equipment for saw sharpening in Western saw mills. The third entitled "Character and Uses of Norton Products as Shown in Norton Hall," is an attractively arranged pamphlet containing 30 pages written about exhibits illustrating the manufacture and uses of abrasive products.

* * *

In a booklet on low pressure natural gas burners for heating systems recently issued by the Economy Burner & Engineering Company, of Pittsburgh, is a description of the application of the "Economy" burners as mounted in three 150 hp. water-tube brick-set boilers.

* * *

Compelled to meet strenuous competition in a prolonged buyer's market, New England manufacturers, deprived of the advantage which they formerly enjoyed through plentiful water-power, are turning in increasing numbers to research as a means of cutting their costs and improving their products. A brief history of the accomplishments of 28 New England companies through this method is contained in a booklet "The Use of Research in Standardization and Simplification," published by the Policyholders Service Bureau of the Metropolitan Life Insurance Company, 1 Madison Avenue, New York City. The brochure contains a part of the compiled data on research in industry gathered during a comprehensive survey of New England industry. It is arranged in four sections each representative of a particular method of attacking the combined problem of simplfying and standardizing manufacturing processes.

Both this pamphlet and the preceding booklet of the series, "The Use of Research in Developing Old Products and Introducing New Ones," may be had free of charge on application to the publishers.

Digitized by Google Original from UNIVERSITY OF MICHIGAN

TRADE NOTES

The Whiting Corporation, Harvey, Ill., has appointed the D. S. Mair Machinery Company, of Houston, as Texas agents. They will handle the complete Whiting and Swenson lines.

* * *

The Donner Steel Company, of Buffalo, N. Y., has ordered three more 300-hp. oil-electric locomotives to be built jointly by the Ingersoll-Rand Company, the General Electric Company and the American Locomotive Company.

* * *

The International Oxygen Company, of Newark, N. J., has taken over the business of the Tariffville Oxygen & Chemical Company, of Tariffville, Conn. This plant will be conducted by a newly formed company, The Tariffville Oxygen Company as the New England division of the International Oxygen Company.

The Tariffville Oxygen Company will continue to manufacture oxygen, hydrogen and acetylene at Tariffville and handle in addition the other products of the International Oxygen Company—nitrogen, primogas, compressed air and liquid air together with the complet International Oxygen Company line of "International" and "Eyeosee" welding and cutting apparatus and supplies.

* * *

A new plant of the Linde Air Products Company, located at 125 Settlement Street, Akron, Ohio, started producing oxygen on September 11. This plant will supply the nearby demand for oxygen used in welding and cutting by the oxy-acetylene process. The addition of this plant to the Linde chain brings the total up to 54. This plant will be operated under the direction of A. Deagon, superintendent.

* * *

In order more adequately to serve the large steel producing group, the Vanadium Corporation of America, 120 Broadway, New York, N. Y., has opened an office at 2245-6 Henry W. Oliver Building, Pittsburgh, Pa., under the direction of Mr. J. Alfred Miller, Jr., general manager of sales of the Vanadium Corporation.

* * *

The American Nickeloid Company, Peru, Ill., has perfected a process for making chromium plate in sheets and strips which can be fabricated without further plating. The plate may be used in many industries as it insures a permanently bright surface which will resist corrosion under the most severe conditions.

* * *

Wellman Bronze Company has been appointed Cleveland representative for the Alemite Die Casting Company, Chicago, for die castings, and by the Keystone Forgings Company, Northumberland, Pa., for brass forgings.

* * *

Oliver Iron & Steel Corporation, Pittsburgh, Morris & Bailey division, announces the appointment of Edgar T. Ward's Sons Company, Chicago office, as its mill representative and warehouse distributor of cold-rolled strip steel in Indiana, Illinois, western Michigan, Wisconsin and Missouri.

The machine shop division of the American Society of Mechanical Engineers in co-operation with the Museum of Peaceful Arts will hold a meeting on measurements at the Engineering Societies Building, New York, October 17. An exhibit of measuring devices will illustrate the discussion.

* * *

W. O. Renkin has been appointed manager of the industrial furnace department of the Combustion Engineering Corporation, 200 Madison Avenue, New York City. Mr. Renkin is well-known as a pioneer in the application of pulverized fuel to metallurgical and industrial furnaces. He has devoted the past 15 years to this particular field of engineering and brings a wealth of practical experience to his new position.

Nature and Uses of Fluorspar

Fluorspar, or fluorite, is a non-metallic crystalline mineral that usually occurs in glassy, transparent isometric crystals, largely cubic, or in cleavable masses. Less commonly it has a granular or fibrous structure, and occasionally it is banded. Fluorspar has a specific gravity of 3.2, is brittle, has a hardness of 4, and can easily be scratched with a knife. Fluorspar is a mineral of many colors, ranging from clear, colorless, or slightly bluish, and glasslike, through various striking hues, of which purple and green are most common; much of it is white and opaque. Chemically it consists of calcium and fluorine in the proportion of 51.1 to 48.9.

Fluorspar has many uses, but its most important use is in the manufacture of steel by the basic open-hearth process, says the U. S. Bureau of Mines, in the statistical report on production of fluorspar and cryolite in 1927. It is also used in the manufacture of alloy steel and ferro-alloys by the electric-furnace process, and in some foundry and other metallurgical operations.

Copies of the Bureau of Mines statistical report on "Fluorspar and Cryolite in 1927," by Hubert W. Davis, may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 5 cents.

Westinghouse Mill Motor Shipped to India

The Tata Iron & Steel Company, of Jamshedpur, India, recently purchased a 4,600 hp., 0-50-120 rpm. reversing mill motor from the Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., U. S. A. A flywheel set accompanying the motor provides the necessary power and consists of two 1900 kw. generators, one 75,000 lb. flywheel, and one 3,500-hp. induction motor, all operating on the same shaft at a speed of 500 rpm. A liquid slip regulator controls the load on the flywheel set.

The motor will be used on a 36-in. roughing mill, for rolling rail and structural shapes. The roughing mill was built by the Brightsides Foundry Company, England. Perin & Marshall, New York City, were the consulting engineers for the company in America.

The Tata Iron & Steel Company is one of the largest of its kind in the world, employing between 60,000 and 70,000 workers. During the World War, a great portion of the steel for Europe was supplied by this company, which is controlled entirely by Indian capital.

NEWS OF THE PLANTS

The Eaton Axle & Spring Company is preparing plans for a $1,000,000 plant to provide 120,000 additional square feet of floor space to its present plant on East 140th Street, according to J. O. Eaton, chairman of the board. The George S. Rider Company, engineers in charge of construction, will be ready for bids within a few days. This will be the company's third plant and will give employment to between 500 and 750 men. This $1,000,000 expansion program is one of the largest industrial expansions announced in Cleveland this year.

* * *

The American Bridge Company is building an acid carrying tank barge with a capacity of 350 tons for the American Steel & Wire Company. The barge will be 100 x 26 x 7 ft. and is for service on the Monongahela River.

The first of 10 covered barges for the Carnegie Steel Company is nearing completion in the Ambridge yards. It is 175 x 26 x 11 ft. Work also is under way on 10 steel pontoons to be used by the erecting department of that company. They are so constructed that the various units may be combined and used as one immense float.

* * *

The earnings of the Inland Wire & Cable Company, Chicago, for 1928, will equal about $6.50 on 102,800 shares of capital stock, according to reports. This compares with $5.11 a share earned in 1927.

* * *

Plans for the reconstruction of several departments of the Vandergrift plant, American Sheet & Tin Plate Company, a subsidiary of the United States Steel Corporation, were recently approved by the corporation, and work has been started that will probably involve an expenditure of about $3,000,000.

The changes planned have been necessitated by developments in methods of sheet steel production. It is understood that the annealing, cold rolling and finishing departments will be affected. The remodeling of these departments when finished will probably not appreciably increase the number of men employed, but will enable the mill to produce a better and more highly specialized product. The Vandergrift mill is the largest of its kind in the world and is generally known to have a greater diversity of product.

* * *

The United Engineering & Foundry Company will furnish the new 6-stand 4-high roller bearing continuous skelp mill to be installed by the National Tube Company, at its National works, McKeesport, Pa. The United Company will also furnish the six hot mills of the new tin plate plant of the Columbia Steel Corporation at Pittsburg, Calif. On this latter job, the Hyde Park Foundry & Machine Company, Hyde Park, Pa., will furnish the six cold mills, Mesta Machine Company the hot mill drives, and Gears & Forgings, Inc., the cold mill drives.

* * *

The Timken Roller Bearing Company has purchased the plant of the Weldless Tube Company, at Wooster, Ohio, from John C. Schultz, receiver, for $200,000. It is expected that operations will be started with 200 men employed within a few weeks. The plant has been idle for four years but the machinery is reported in good condition.

* * *

Plans are now complete for starting construction of the $10,000,000 plant of the Davison Coke & Iron Company on a 140-acre tract here. George S. Davison, president of the Gulf Refining Company and the Allen S. Davison Company, will head the new firm. It is intimated that the company intends to be producing pig iron and cement by next June and coke and by-products in October, 1929. The plant at first will consist of a blast furnace with a capacity of 600 tons a day, a coke plant handling 1000 tons of coal daily and a cement plant with annual capacity of 1,000,000 barrels.

* * *

The Lockhart Iron & Steel Company resumed operating its McKee's Rocks, Pa., works this week with 29 puddling furnaces working double turn and the finishing department five days a week.

* * *

A plant is to be erected in Buffalo by Bliss & Laughlin, Inc., Chicago and Harvey, Ill. The Buffalo plant will produce the same lines as are now being manufactured at Harvey and have been since 1891, covering cold-drawn steel in rounds, squares, hexagons and flats, and screw stock in open-hearth and special alloy grades and polished and ground shafting.

Paul J. Kalman is president of Bliss & Laughlin, Inc. Walter R. Howell, vice president and general manager, will be in direct charge.

COMING MEETINGS

Nov. 13-17—American Institute of Steel Construction, Inc., sixth annual convention at Biloxi, Miss. Chas. F. Abbott, executive director, 285 Madison Avenue, New York City.

* * *

Nov. 19-24—The Second International Conference on Bituminous Coal at Pittsburgh, auspices of the Carnegie Institute of Technology. Prof. Sumner B. Ely, secretary, Carnegie Institute of Technology, Pittsburgh.

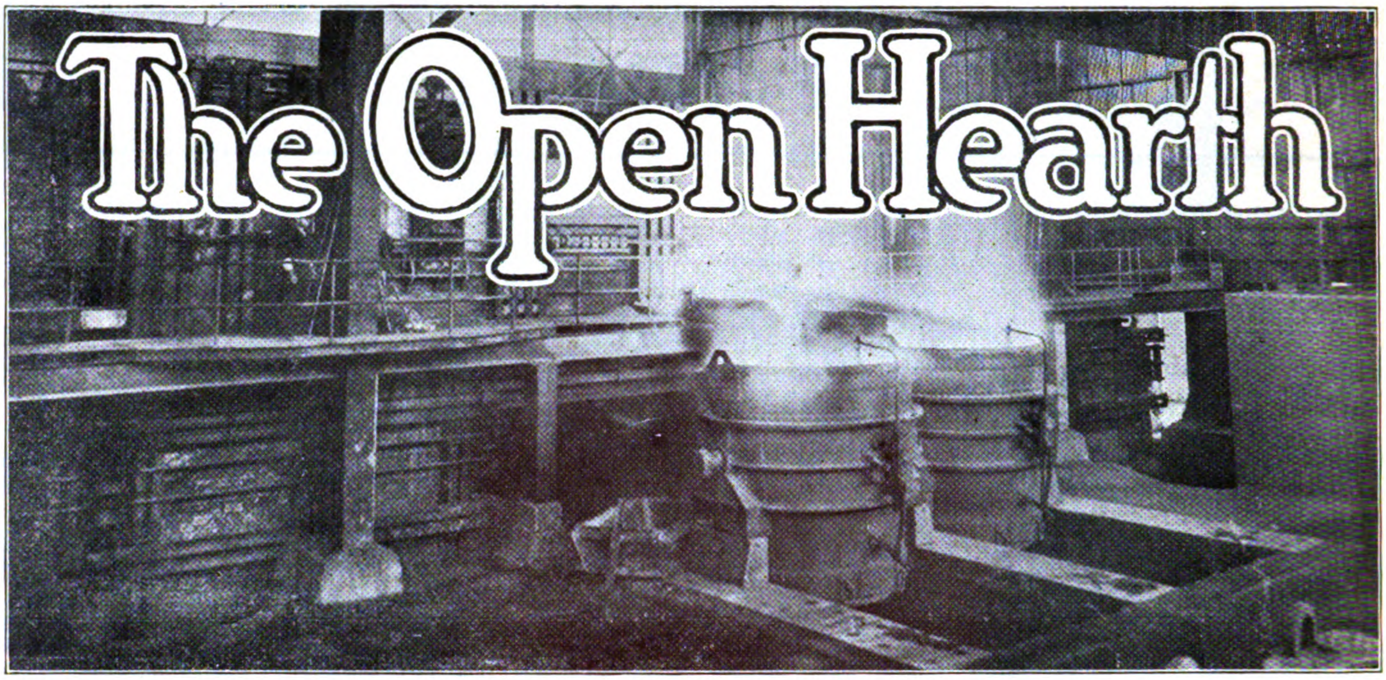
* * *

Dec. 3-8—National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City. Fred W. Payne, manager, Grand Central Palace, New York.

* * *

Dec. 3-8—Annual meeting, American Society of Mechanical Engineers, Engineering Society Building, New York City. Calvin Rice, secretary, 29 W. Thirty-ninth Street, New York.

The Open Hearth



Earl D. Townsend has opened an engineering office in Pittsburgh and is prepared to undertake mechanical and structural design. Mr. Townsend had previously been a designer with the Aetna Standard Engineering Company and was formerly chief draftsman for the Pennsylvania Engineering Works, New Castle, Pa., and plant engineer for the Standard Gage Steel Company, at Beaver Falls. He is well known among engineers in the Pittsburgh district.

* * *

Harry Saxer who has been superintendent of blast furnaces at the Aliquippa works of the Jones & Laughlin Steel Corporation has been made assistant general superintendent. Mr. Saxer has been identified with the company for 20 years, first at the Eliza furnaces and later as assistant superintendent of the furnaces at the Aliquippa works.

R. A. Field who has been assistant superintendent of blast furnaces at Aliquippa works becomes superintendent.

* * *

J. E. Sullivan, formerly superintendent of blast furnaces and ore docks of the Sparrows Point, Md., plant of the Bethlehem Steel Company, has been made vice president of Edgar E. Brosius Inc., Pittsburgh, designer and manufacturer of grab buckets, steel mill equipment, etc.

* * *

S. M. McManus has been elected president of the Muskogee Iron Works Inc., Muskogee, Okla., succeeding C. L. N. Haines. Mr. McManus will continue his duties as general manager of the plant. H. H. Elliott has been elected vice president.

* * *

Robert T. Wilson, Pittsburgh, has been elected a member of the board of directors of the Newton Steel Company, Youngstown, Ohio, to fill the unexpired term of Harold A. Taylor, who recently resigned.

* * *

L. C. Wilson, president of the Federal Malleable Company, Chicago, will become assistant to the president of the Interstate Iron & Steel Company, also of Chicago. Mr. Wilson, a member of the American Foundrymen's Association, was elected a director for 1926-28. He was associated at one time with the Harbison-Walker Refractories Company and later with the Chain Belt Company, Milwaukee, where he became general manager.

* * *

Mr. N. L. Mortensen has been appointed chief engineer for The Cutler-Hammer Manufacturing Company, Milwaukee, effective September 1.

Mr. T. E. Barnum, former chief engineer, has been appointed consulting engineer for the company, in which position he will be able to give uninterrupted attention to engineering problems and outside engineering relations.

Mr. Mortensen has been connected with Cutler-Hammer for 21 years, the last five of which have been as assistant to Mr. Barnum.

* * *

Mr. Walter G. Hildorf has been placed in charge of all metallurgical work for the Timken Steel & Tube Company, Canton, Ohio. For the past several years Mr. Hildorf has been metallurgical engineer for the Reo Motor Car Company, Lansing, Mich.

* * *

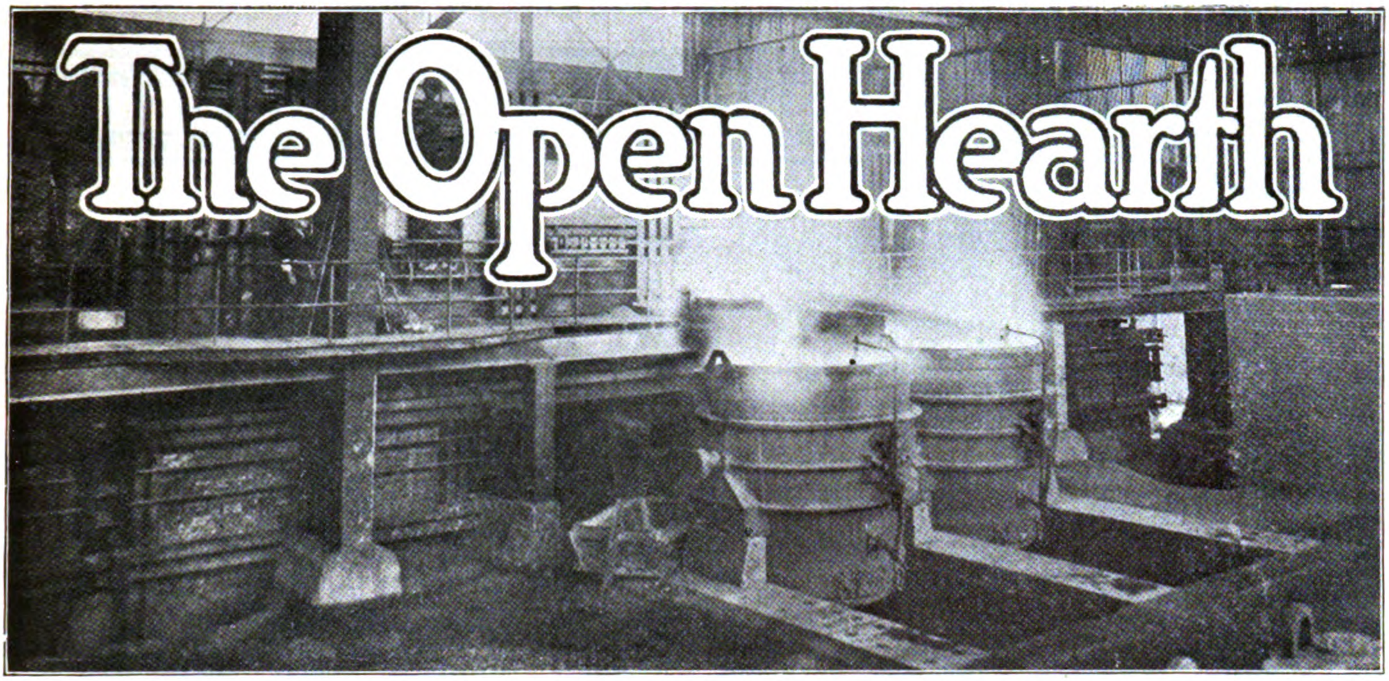
John W. Mahon has been appointed superintendent of the cold strip department at the Warren works of the Republic Iron & Steel Company, Youngstown, Ohio, succeeding H. A. Fisher. Mr. Mahon had formerly been employed at the Superior Steel Company, Carnegie, Pa., for 25 years.

* * *

J. S. Stanier has been appointed special mill representative by the Newton Steel Company, Youngstown, Ohio, and will travel out Newton Falls, Ohio. He formerly was associated with the West Penn Steel Company.

* * *

Peter J. Gordon, veteran general superintendent for Republic Iron and Steel Company, and his assistant, Thomas J. Bray, have been made assistants to the vice president, William M. Neckerman. H. B. Carpenter, who came to Republic lately from the Chicago district, will succeed Mr. Gordon.



The Open Hearth

W. B. Topping, who last month announced his resignation as general sales manager of the Republic Iron & Steel Company, Youngstown, Ohio, has been appointed general manager of western sales for the Bethlehem Steel Corporation, President Eugene G. Grace, of the Bethlehem Corporation, announced recently. The appointment becomes effective November 1.

Mr. Topping is the son of John A. Topping, chairman of the Republic Steel Company. He joined the Republic organization in 1905 as a sales representative at Birmingham, Ala. He became assistant manager of sales in 1915 and was promoted to the managership a few years later.

* * *

R. J. Working has been named district sales manager in Cincinnati for the Central Alloy Steel Corporation, Massillon, Ohio. For a number of years he has been connected with the sales department at the corporation's general offices in Massillon.

* * *

A. J. Diefendorfer has lately been made assistant superintendent of the rolling mill department of the Farrell works of the Carnegie Steel Company, Farrell, Pa.

* * *

C. D. O'Connor has been appointed master of river transportation for the Vesta Coal Company, subsidiary of the Jones & Laughlin Steel Corporation. Mr. O'Connor had been superintendent of the Aliquippa and Southern Railroad. Captain James A. Rankin, who has been with the Vesta fleet for more than 12 years, has been made assistant master of transportation.

* * *

Hugh Morrow, president of the Sloss-Sheffield Steel & Iron Company, Birmingham, Ala., has just been re-elected president of the Alabama Mining Institute.

* * *

B. E. Kibbee, vice president in charge of sales of the Sharon Steel Hoop Company, has been elected a director of the company, filling an existing vacancy.

J. Leonard Replogle, for many years a leading figure in the steel industry, has become a special partner in the New York stock exchange firm of Harris, Winthrop & Company. Mr. Replogle was formerly head of the Replogle Steel Company. He is a director of the Warren Foundry & Pipe Corporation, Wharton, N. J.

* * *

F. C. Biggert, desiring to devote his time entirely to engineering and research problems, has relinquished the presidency of the United Engineering and Foundry Company, Pittsburgh, and George T. Ladd, vice chairman of the Combustion Engineering Corporation, has been elected to succeed him. Mr. Ladd, early in his career, was associated with the rolling mill and roll business, and later founded the George T. Ladd Boiler Company which was acquired by the International Combustion Engineering Corporation some years ago, at which time he became president of the Ladd Water Tube Boiler Company and the Heine Boiler Company, subsidiaries of the International Corporation. Mr. Biggert will remain with the United Engineering and Foundry Company as vice president and senior engineer.

Book Review

Finding and Stopping Waste in Modern Boiler Rooms, edited by Geo. H. Gibson, Mem. Am. Soc. M. E.; published by Cochrane Corporation, Philadelphia, Pa., and for sale by "Blast Furnace and Steel Plant;" 804 pages, 5 x 7 in.; numerous charts and illustrations; flexible cloth binding. Price $3.00.

This is a reference book of text, tables and charts compiled from papers read before engineering societies, books, articles in technical periodicals, publications of the U. S. Bureau of Mines, and other original sources, and put into convenient form for owners, managers, engineers, firemen and others interested in increasing and maintaining boiler plant economy. The five sections are on the subjects of fuels, combustion, heat absorption, boiler efficiency and testing, and feed water heating and conditioning.

THE STEEL PLANT ROLL TURNER AND DESIGNER

George R. Evans

Twenty-one years of experience has enabled George R. Evans to successfully fulfill the position of roll designer at the Hamilton and Ontario works of the Steel Company of Canada, Ltd.

Figuring Efficiency of Steel Mills*

By Fred C. Smith

A problem that frequently occurs in connection with rolling mill practice is that of comparing the relative efficiency of different mills and of performances of the same mill at different times. Obviously, mere comparisons of tonnage produced are not sufficient for this purpose. Nor does the amount of time lost in performance give any indication of the efficiency of the mill. The most practical method is to compare actual production with a theoretical maximum. If this comparison is made on the basis of actual rolling time, time lost due to unavoidable causes having been deducted, we have a measure of the true efficiency of the mill.

Suppose the following data (a) are available for a given run:

Example I—

Collar diameter of finishing roll, $12\frac{1}{8}$ in. = 1.0104 ft.
Product: round bars.
Diameter of bars, ½ in. = 0.0417 ft.
Weight produced, 201,060 lb.
Total available time, 480 min.
Delays, 48 min.
Speed of finishing roll, 372.9 rpm.

What is the efficiency of the mill for this run?

The maximum production of a theoretically perfect performance is calculated as follows: The pitch diameter, in lineal feet, of any roll is $P. D. = C. D. - 0.7071S$; where C. D. is the collar diameter of the roll in feet, and S is the largest diameter of the finished product, measured in a plane perpendicular to the axis of the roll. In the given instance,

$$P. D. = 1.0104 - (0.0417 \times 0.7071) = 0.9809 \text{ ft.}$$

Multiplying the pitch diameter by π gives the pitch circumference of the roll, which is equivalent to the amount of the product, in lineal feet, delivered per revolution; i.e.,

$$0.9809 \times 3.1416 = 3.0816 \text{ ft., pitch circumference.}$$

Note—The data used in this and the following examples are taken from actual performances of a rolling mill.

The speed of the roll, in revolutions per minute, times the pitch circumference gives the possible delivery in lineal feet per minute:

$$3.0816 \times 372.9 = 1149.1 \text{ ft. per min.}$$

Multiplying this figure by the actual rolling time in minutes gives the maximum possible production for the given period:

$$(480 - 48) \times 1149.1 = 496{,}411 \text{ ft.}$$

This figure may be expressed in pounds by multiplying it by the weight per foot of the product—in this case, 0.668 lb. per ft.; in this way, we obtain a figure for perfect performance:

$496{,}411 \times 0.668 = 331{,}603$ lbs., production under perfect conditions, with which may be compared the figure of actual production, 201,060 lb.

The coefficient of efficiency may then be computed by dividing the actual production by the theoretical; expressed in per cent, the result is:

$$E = 201{,}060 \div 331{,}603 = 60.6 \text{ per cent.}$$

In this example, the coefficient of efficiency will be the same, regardless of whether we figure the efficiency in terms of weight or in terms of length rolled. In the latter case, we reduce the actual production to feet by dividing it by the weight per foot of the product, and take the ratio between that figure and the figure in feet of the theoretical delivery:

$$E = 201{,}060 \div 0.668 \div 496{,}411 = 60.6 \text{ per cent.}$$

This coefficient will never equal 100 per cent because:

1—There is always a certain amount of "slip" between the rolls and the bar.

2—The rolling is not continuous. A time allowance must be made at the furnace for the longer time taken for a pass as the diameter decreases and the bar lengthens. This cannot be exactly estimated. Consequently, there will be a gap between the end of one bar and the front of the following one.

(To be continued)

---

*Iron and Steel of Canada.

THE STEEL PLANT BRICK MASON

Start Ceramic Course at Penn State

The ceramic engineering college year at Penn State opened September 19, the instructors for the year are the same as last year, Prof. J. B. Shaw, head of the department and George J. Blair, instructor. Much new equipment has been added during the past summer and some modifications have been made in the laboratories resulting in considerable increase in space for work. The total registered for this semester is 32.

Slagging Effect of Coal Ash

The operation of boiler furnaces with mechanical stokers at high ratings has greatly reduced the life of refractories in arches, side walls, and bridge walls. The action of slag from coal ash of low fusibility and high iron content, as in the case of many Illinois coals, is especially severe and causes a rapid erosion of the refractory.

In an investigation of the slagging effect of Illinois coal ash on refractories a laboratory testing method was sought which would determine the relative resistance of different bricks to such slags in terms which might be correlated with the results obtained in service in boiler furnaces. The simulated service test was found most applicable for this purpose. Difficulty was found in obtaining equal heat treatment and uniform slag application on test bricks under conditions representative of boiler furnace operation. As a result of considerable effort and trial of several methods, a furnace and a testing method were developed by the Engineering Experiment Station of the University of Illinois which gave a very satisfactory simulated service test.

Circular No. 17 contains a detailed description of the slagging test furnace and gives methods of conducting tests with the furnace, as well as some of the results obtained with the use of synthetic slag and with coal-ash slag. Copies may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Ill.

Lavino Gets Open Fire Kiln

E. J. Lavino & Company, Plymouth Meeting, Pa., is modernizing its plant by installing the very latest type of open-fire Dressler kiln. This kiln is known as a multiburner type in which the heat is applied through a great number of very small burners on each side of the kiln.

E. C. Henderson is superintendent of masons at the Steelton, Pa., plant of the Bethlehem Steel Company. He also supervised the paving of Steelton city streets.

Thermal Expansion of Firebrick

Thermal expansion data for fireclay brick have important use both in commerce and in the development of ceramic theory. In commercial work such data are used in the design of structures for operation at high temperatures and in the development of structural units which will withstand repeated temperature changes. From the standpoint of theory, the thermal expansion of a burned-clay product is one of its fundamental physical properties. It is of particular scientific interest because different brands of fireclay bricks expand to different degrees when heated; the expansions are seldom proportional to the increase in temperature, but are subject to very marked and characteristic irregularities; and silica and its various allotropic modifications, which are present in varying concentrations in fireclay bricks, have very high and irregular, but characteristic, expansion when heated.

Bulletin No. 181 of the Engineering Experiment Station of the University of Illinois is the report of an investigation undertaken to determine the thermal expansion behavior of 20 brands of fireclay bricks for the temperature range from 25 deg. C. to approximately 900 deg. C., along with other properties which would be of interest in connection with these data. These brands of bricks were chosen so as to include a wide range of properties and examples of the principal types manufactured in the United States. Copies may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Ill.

After Diaspor—What?

By A. F. Greaves-Walker*

The use of diaspor by the manufacturers of high grade refractories has increased by leaps and bounds during the past eight years. At the present time all of the large manufacturers depend upon this mineral for fire brick having pyrometric cone equivalents above 36.

Diaspor first came into use for refractories purposes about 1907, when the late William G. Hipp of Massillon, Ohio, shipped a carload to his plant for experimental purposes. It was not until after the war, however, when the demand became insistent for super-refractories that the industry at large began to take interest in the mineral.

---

*Professor, ceramic engineering, North Carolina State College, Raleigh, in Ceramic Age.

The only known commercial deposits of diaspor, which is hydrous alumina (Al_2O_3 H_2O) are located in east central Missouri. They are confined to a relatively small area and the reserves available at the present time only slightly exceed 1,000,000 tons. In this total is included all diaspor and burley clay which will analyze over 55 per cent Al_2O_3. Of this total one large refractories company owns approximately 500,000 tons or one half, the balance being divided among eight of nine others.

It will be readily seen that within a few years the reserves of several manufacturers will have become exhausted and this fact is causing not a little speculation as to the source of future supplies of high alumina material which will serve as a substitute.

Several possibilities offer a solution of the problem, among which are: (1) Cyanite; (2) Bauxite; and (3) Georgia kaolins.

Cyanite

The first of these, cyanite (Al_2O_3 SiO_2) has already been tested out commercially to such an extent that it may be said to have established itself as a valuable refractory.

Practically all of the cyanite used in this country so far has been shipped from India and is of the massive variety. One mine in Virginia has been producing a small tonnage for several years past, but the large and practically inexhaustible deposits of this country are located in western North Carolina. It is these deposits which the refractories manufacturers will have to turn to if the use of cyanite becomes general in high alumina refractories.

The North Carolina cyanite occurs as small crystals in a silicious schist and it will be necessary, therefore, to process it by some flotation or concentration method in order to make it available. As it expands on heating it will be necessary, also, to calcine it before using. While the cost of this processing need not be high, it will certainly considerably increase the cost of cyanite brick over the present cost of diaspor brick.

Bauxite

The use of bauxite (Al_2O_3 $2H_2O$) like cyanite, necessitates processing of the ores. A considerable amount of research work has been done on this mineral in an effort to use it for refractories. Because of difficulties encountered in the past an idea has become prevalent among some manufacturers that it is not suitable for the purpose.

While it is true that shrinkage of bauxite brick in use has heretofore presented a serious problem, no manufacturer has been properly equipped to "dead burn" the ore. That this can be done has never been questioned and the fact remains that very satisfactory refractories have been made from ore calcined at 2900 deg. F. An additional 100 deg. would make an even more satisfactory product.

Difficulty in bonding the calcined ore has been encountered but this has only been the case when attempts have been made to eliminate clay bonds entirely or use plastic fire clays of low bonding qualities. The use of high grade refractory bond clays has proven entirely successful.

It is, of course, evident that the "dead burning" of bauxite would have to be done in rotary kilns.

Georgia Kaolins

During the past five or six years the refractories manufacturers have been considering the future possibilities of the Georgia kaolins and many are convinced that they are bound to play an important role.

The deposits extend in a wide band across Georgia from Augusta to Columbus, but not all of the clays are suitable for the manufacture of refractories. Only those classed as hard kaolins and those of the bauxite type will serve this purpose.

While a large majority of the deposits have an alumina content ranging from 35 to 40 per cent, and a pyrometric cone equivalent of from 34 to 36, there are many containing bauxitic clays which range from 41 to 56 per cent alumina and having pyrometric cone equivalent of from 37 to 40, or practically the same as the diaspor clays.

The shrinkage of these clays is higher than diaspor and it would be necessary to calcine from 60 to 70 per cent of the batch to at least cone 20. This would necessitate rotary kiln treatment if the material was used on a large scale.

These clays have been used commercially for a sufficient length of time to be considered beyond the experimental stage. They have given results equal to any other high alumina product in practically every type of service and have also lent themselves to all of the processes, dry press, stiff mud and soft mud.

One type of clay found in these deposits and known locally as "chimney rock" seems to offer exceptional possibilities. It resembles very much the diaspor clays in appearance except that it is white. Like the diaspor clays it varies in alumina content, but is always above 40 per cent and, like the kaolins with which it occurs, it has a high shrinkage.

Should bauxite find wider use in the future it is the Georgia deposits which will probably supply the demand. These deposits have not greatly interested the aluminum manufacturers because they are low grade, seldom running much over 56 per cent alumina. The pyrometric cone equivalent is from 39 to 41, however, which makes them eminently suitable for super-refractories.

It is quite evident that having established lines of high alumina refractories which are constantly finding wider use, the manufacturers must continue their manufacture after the diaspor deposits are depleted. It is just as evident also that cyanite, bauxite or kaolin will serve as excellent substitutes and that the next few years will see some new and interesting developments in the high alumina field.

Spalling of Refractories in Oil-Fired Furnaces

It has been the common experience of those using fuel oil for firing boilers that the refractories of the furnaces fail because of spalling, rather than from slagging, whereas slagging is the more common trouble

Digitized by Google Original from UNIVERSITY OF MICHIGAN

with furnaces fired with powdered coal. The relatively small amount of slagging in oil-fired furnaces is to be expected because the ash content of fuel oil is less than one-tenth of one per cent, whereas that of the coal may be from 8 to 18 per cent; there has been, however, no proven explanation of the very common breaking up of the refractories walls by spalling, although that of strains caused by temperature variation has seemed the most reasonable one.

The boiler furnace refractories investigation, which the U. S. Bureau of Mines has been conducting in cooperation with the American Society of Mechanical Engineers, has included a study of furnace conditions of two large boilers using Illionis coal and one using fuel oil. The low fusion temperature of the ash of the coals made slagging a serious cause of trouble in the coal-fired furnaces, whereas the oil-fired furnace showed the usual failures from spalling. A special comparative analysis was made of the measurements taken in the coal and oil-fired furnaces in the attempt to elucidate the reason for the greater spalling.

The rate of heat liberation in the oil-fired was much higher than in the powdered-coal furnaces but the maximum temperatures of the gases observed were the same, 2800 deg. F. The maximum temperatures measured were somewhat higher in the oil-fired furnace at the positions where the flame impinged on the wall.

The temperature gradient plotted for the first 6 in. of the hot side of the furnace wall under approximately constant operating conditions was not greater for the oil-fired than the coal-fired furnace.

The rate of change in temperature of the furnace walls when the furnaces were banked or fired up were nearly the same. The rate and frequency of change of temperature during steaming were not greater in the oil-fired than in the powdered-coal furnace walls; these measurements were taken at ½ in. and further from the hot surface and although they do not predicate the possibility that the small temperature variation at the hot surfaces of the walls were not the same, yet there is not sufficient evidence to warrant the acceptance of change of temperature as the only cause of the greater spalling in the oil-fired furnace and differences in some other factors may be expected.

The chemical composition of the ash of the fuels and of the slags from the walls differed materially in that those from the oil-fired station were higher in sodium and lower in iron and calcium; the softening temperatures were low for all. Microscopic examinations of the slags by the Columbus Station of the Bureau of Standards have shown the presence of a mineral in the oil slag not previously found in coal-ash slag which has been identified as asodium-calcium silicate.

It is therefore possible that some mineral or minerals formed in the slag or in the combination of slag and brick which was sensitive to thermal shock; or the mineral may have had a much different coefficient of thermal expansion than the brick, and fracture resulted from the difference in the contraction of cooling. The relatively deep fractures found on the side and front walls bear out the former conception, and the thin fractures on the bridge wall, the latter.

—Department of Commerce.

Magnesite*

By Hugh M. Henton

Crude magnesite may be marketed as mined except that lime carbonate and silicious waste may be removed by a simple dressing or sorting operation. More often the crude is calcined so as to give either "light-burned" or "dead-burned" magnesia. The light-burned is sometimes known as "caustic" and is the product of a moderate kiln temperature. The "dead-burned" magnesia is the product of a furnace temperature so high as to remove all carbon dioxide and give an incipient fusion if sufficient impurities are present.

The mining of the magnesite varies from the open cut or quarry methods to underground stoping of various kinds. In some of the North American deposits, the very latest machinery is employed for both breaking and handling of the raw magnesite. In some of the European deposits hand work is the rule, and little machinery is used at the mine. This last condition exists because of the low wage scale.

Hand sorting is resorted to in most of the mines, the object being to remove the larger pieces of waste before crushing. In some mines further sorting is done, after a preliminary crushing. Occasionally a washing operation is used to remove the fines, which often contain silicious impurities. No machine to do this sorting has been a commercial success. Occasionally there is only a very slight difference in appearance between a good magnesite and one containing high lime. This complicates the sorting problem. After the sorting and washing operations one operator crushes to one-inch diameter and feeds to a rotary kiln by means of an automatic feeder. If the material is to be light-burned, it is fed through the length of the kiln in about 45 minutes; if to be dead-burned it goes through much more slowly and the temperature is much higher.

The dead-burned magnesite is often mixed with iron oxide (2 to 5 per cent) in order to make a bond which will hold the particles together in small, nearly spherical globules. Sometimes the iron oxide is present in the crude magnesite as it comes from the mine or quarry. The kiln product is called "ferro-magnesite." The temperature for its formation is just above 1,500 deg. C. The magnesium silicate forms a binding material to hold magnesia and iron oxide.

Foreign Countries

Austria—Consul P. Hurley reports that the Austrian magnesite industry is prosperous, notwithstanding the decreased exports to the United States. The European countries generally are beginning to use more magnesite and the situation is favorable to Austrian producers. The deposits are so extensive that 70 per cent of the world's needs can be supplied if the mines are worked at full capacity.

Six magnesite companies handle the bulk of the production in Austria. One company has three plants in Styria, and one plant in lower Austria. Another company has four plants in Styria. These employ 2,500 workers, and the industry is a considerable factor in the welfare of the nation.

---

*From "Mineral Industry," McGraw Hill Book Co., Inc.

Greece—An article descriptive of the Grecian magnesite mines on the island of Euboea was written by J. R. Thoenen of the U. S. Bureau of Mines.† According to his description, crude hand methods, relics of past years, still survive, along with some rather troublesome local conditions. The veins vary in size and occur in serpentine. The magnesite is very pure and is sold principally for plastic magnesia. One company has holdings comprising some 5,000 acres.

Canada—The production of caustic and dead-burned magnesite in Canada was 7,337 tons with a value of $230,309. The townships of Greenville and Harrington in Argenteil County, Quebec, have the principal producing mines. Hydro-magnesite occurs in British Columbia, but has not been extensively developed. It is powdery and needs a different treatment from the regular hard magnesite. In Quebec the production showed a 60 per cent increase in tonnage and a 69 per cent increase in value over the 1926 figures.

Other foreign countries occupied relatively the same position in the industry that they had the previous year. British India has not had any recent development. Manchurian deposits have not proven highly profitable. African deposits are yet in the exploration and development stage. Little is heard from the Russian deposits.

United States

Production and imports—The total production in the United States of crude magnesite for 1927 was 121,490 tons with a declared value of $1,090,550, or $8.98 per ton. While the average value is about the same as in 1926, the total tonnage shows a decrease of 9 per cent. Imports for 1927 were 891 tons of crude magnesite, 88 per cent coming from Greece; 9,463 tons of light-burned magnesite, 60 per cent from India and 33 per cent from the Netherlands; and 49,873 tons of dead-burned magnesite, 74 per cent from Austria and Czechoslovakia. Over 1926, the imports show a 46 per cent increase in crude, a 36 per cent decrease for caustic calcined, and a 35 per cent decrease in dead-burned. The decrease is probably due to the increased tariff, effective for November and December.

California—Three mines in California produced 43,750 tons of crude magnesite valued at $507,500. One deposit is being worked to furnish raw material for manufacture locally of epsom salts, basic and light magnesium carbonate, and glauber salts. The tariff increase should be of considerable benefit to California operators because a large part of their product is light-calcined, and as such, protected by the increased duty.

Washington—Dead-burned magnesite was produced at the only property in Washington which was operating in 1927. The Northwest Magnesite Company operated two of its rotary kilns at the Chewelah plant. An article by S. S. Siegfus gives much information on the geology of the Washington deposits.*

The magnesite occurs as lenticular deposits in the Stensgar dolomite of Stevens County. The dolomite belt is about 20 miles long and the principal deposits of magnesite are: the Red Marble quarry, the Finch, the Allen-Moss, and the Keystone. The Red Marble is the largest but the least explored; here the magnesite is more highly colored and of finer grain than at the other quarries. The Finch deposit is next in size, and gives almost all of the present production. It lies at the opposite (north) end of the dolomite belt.

Book Review

Practical Industrial Furnace Design. Matthew H. Mawhinney. 318 pp. 1928. John Wiley & Sons, New York. $4.00.

This is a valuable work—all the more welcome because the design of industrial heating furnaces is today an important engineering problem, and the literature, in book form, is very scanty.

The book is based on Mr. Mawhinney's articles which for more than a year (beginning in December 1926) appeared serially in "Forging-Stamping-Heat Treating."

The intent has been to produce a practical work, and in this the author has succeeded admirably. Occasionally a mathematical formula is introduced but, in general, the presentation of theory has been minimized. For theory, the reader is at times referred to "Industrial Furnaces," by Prof. W. Trinks, under whom the author was formerly a student.

The author deals concisely with the practical solution of the problems ordinarily encountered in selection, design, and operation of industrial heating furnaces as distinguished from melting furnaces. Prominent among these problems are, (1) the choice of fuel, complicated by the availability of modern types of fuel, comparative costs and merits, and specific requirements of industrial processes; (2) selection of type and dimensions of furnace; (3) consumption of fuel, and saving of heat; (4) furnace materials, including the application of high-temperature refractories and heat-resisting metals developed commercially only during recent years. Chapters are included also on methods of mechanical handling of material, on temperature measurement and furnace control, and on practical problems of furnace design.

The book merits praise for its clarity. There are several other commendable features which should be found in all technical books but which, unfortunately, are sometimes overlooked by authors and publishers alike. The drawings are clear, and the letters and figures thereon are large enough to be easily legible; the preface and the introductory chapter definitely state the scope and purpose, and let the reader know just what the book intends to accomplish; and in some cases the subject matter is concisely summarized in the form of "conclusions."

Since it affords access to much information which is not found elsewhere—or found only by extensive searching of scattered material—the book will prove very useful.

—E. H. McC.

---

†Eng. Min. Jour., April 21, 1928, vol. 125, p. 644.

*Eng. Min. Jour., November 26 1927, vol. 124, 853.

SAFETY FIRST IN THE STEEL PLANT

The National Safety Council; Its History, Progress and Mission

Organized to prevent accidents everywhere, the National Safety Council today is financed by 4,650 members, representing 153 different kinds of industries, government departments, community safety councils, educational institutions libraries, chambers of commerce, motor clubs, insurance companies, various national, state and local professional, trade and business organizations and public-spirited citizens. It is a co-operative, non-profit making institution, which is endeavoring to promote safety, sanitation and health in the industrial, public and home life of the American people. Its officers and 1,000 committeemen serve without financial compensation, meeting regularly to determine its policies and program. The organization serves as a national clearing house of accident prevention information, maintaining its headquarters at 108 E. Ohio Street, Chicago, where a staff of more than 80 employees devote all of their time to safety work.

M. H. Stearns, safety director since 1917 for Donner Steel Company, Buffalo, N. Y., has given, in an exclusive paper in this issue of Blast Furnace and Steel Plant, a review of accident prevention.

Record Made at Farrell

The Farrell Works of the Carnegie Steel Company had a total of 7 lost-time accidents from January 1 to May 1, 1928, for a total of 1,601 employees working 1,433,633 man-hours. This plant, up to May 1, 1928, had not had a fatality since April 27, 1925.

Good Showing at Bethlehem

The Bethlehem Steel Company, Bethlehem, plant, employing over 11,000, including the main office, had a total of 29 lost-time accidents, with one serious one, during the first quarter of 1928. This compares with 96, including three serious cases, for the first quarter of 1927, showing a reduction of approximately 70 per cent. Moreover, these 29 lost-time accidents for the first quarter of 1928 show an average of a trifle under 10 per month as compared with a monthly average of 28.7 for the year 1927, and 48 for the year 1926.

Free Consultation Service

The National Safety Council maintains a staff of trained safety engineers who assist members with their safety problems.

First-Aid Methods for Treating the Injured

Surgeon General H. S. Cumming, of the U. S. Public Health Service advises that everyone become familiar with first-aid methods for treating the injured. First-aid has been defined as the temporary care of an injured person by simple, commonsense methods, based on principles of medicine and surgery that may be applied easily by persons not professionally trained in those subjects. It should be noted that the work of first aid ceases when the injured person has been turned over to the care of a physician.

The common injuries include wounds with bleeding and possible infections, dislocation and fracture of bones, burns, including those caused by chemicals and asphyxia, or cessation of respiration. The principles upon which first-aid are based are as follows:

The most important thing in the care of the injured person is prevention — the reduction of accidents to a minimum by education and legislation. But as this minimum can never be zero, it is well to bear in mind the fundamental principles in first-aid care, which are as follows—

1—Asepsis or cleanliness in caring for open wounds.

2—Control of hemorrhage by pressure and position of injured part.

3—Treatment of shock by keeping patient at rest and warm and by giving simple stimulants.

4—Artificial respiration in asphyxia, electric shock, etc., combined with the use of pure oxygen in carbon monoxide cases.

5—Asepsis in treatment of burns; protection from air if this can be done with aseptic methods; antisepsis and some relief of pain by use of picric acid gauze.

6—Immobilization of dislocations and fractures.

7—Transportation by methods that will not increase the extent of the injury.

In addition to the benefits gained by the early care of the injured, first-aid has been found actually to tend to lower accidents by making people more careful.

—From the United States Public Health Service.

Prevention of Blindness

The principal forces now engaged in the work of preventing blindness and conserving vision throughout the United States will gather in New York City for a series of conferences, November 26-28.

Digitized by Google Original from UNIVERSITY OF MICHIGAN